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(54) Method for producing surface-treated paper and dry end of a paper machine

Verfahren zur Herstellung von Papier mit veredelten Oberflächen und Trockenpartie einer Papiermaschine

Procédé de fabrication de papier à surfaces travaillées et partie sèche d'un machine à papier

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(56) References cited:

EP-A- 0 427 887	**EP-A- 0 626 478**
DE-A- 3 741 128	**DE-U- 9 414 963**
US-A- 3 658 642	**US-A- 5 269 074**
US-A- 5 377 428	**US-A- 5 416 980**

- **PATENT ABSTRACTS OF JAPAN vol. 17, no. 225 (C-1055), 10 May 1993 & JP-A-04 361695 (SANYO KOKUSAKO PULP CO LTD)**

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a method for producing surface-treated paper, in particular fine paper.

[0002] Further, the present invention relates to a dry end of a paper machine intended for the production of surface-treated paper which has a forward dryer section, also referred to as a "predryer section" or a "main dryer section", and a subsequently arranged on-line or off-line finishing section.

[0003] In the prior art, in multi-cylinder dryers of paper machines, twin-wire draw and/or single-wire draw is/are employed. Drying groups applying a twin-wire draw include two wires which press the web, one from above and the other one from below, against the heated cylinder faces of the drying cylinders. Between the rows of drying cylinders, which are usually horizontal rows, the web has free and unsupported draws. The free draws are susceptible to fluttering which may cause web breaks, in particular since the web is still relatively moist and, therefore, has a relatively low strength. For this reason, in recent years, increasing use has been made of a single-wire draw in which each group of drying cylinders has only one drying wire. The web runs on support of the single drying wire through the entire group so that the drying wire presses the web on the drying cylinders against the heated cylinder faces thereof, and whereas, on the reversing cylinders or rolls arranged between the drying cylinders, the web remains at the side of the outside curve. Thus, in a single-wire draw, the drying cylinders are placed outside the drying wire loop and the reversing cylinders or rolls are situated inside the drying wire loop.

[0004] In prior art normal groups having a single-wire draw, the heated drying cylinders are typically arranged in an upper row and the reversing cylinders are therefore arranged in a lower row, below the upper row. The upper row and lower row are generally horizontal and parallel to one another. The assignee's Finnish Patent No. 54,627 (corresponding to the assignee's U.S. Patent No. 4,202,113, the specification of which is hereby incorporated by reference herein) describes an arrangement wherein normal groups having a single-wire draw and so-called inverted groups having a single-wire draw are arranged one after the other. In typical inverted groups, e.g., of the type shown generally in US 4,202,113, the heated drying cylinders are arranged in the lower row and the reversing suction cylinders or rolls are arranged in the upper row. This arrangement utilizing normal and inverted groups enables a principle objective to be achieved, i.e., to dry the web symmetrically from both of its sides.

[0005] With respect to additional prior art, reference is made to published International Patent Applications WO 88/06204 and WO 88/06205 (assigned to Beloit Corp.) which describe dryer sections

[0006] Accordingly, in the following description, the terms "normal (drying) group" and "inverted (drying) group" are used to denote the cylinder groups having a single-wire draw as described above, as such is accepted terminology to those skilled in the art. The expression "single-wire draw" is equivalent to the terms "single felting" and "single tier" which are interchangeably used in the art. Similarly, the expression "twin-wire draw" is synonymous with the expression "double felting" as used in the art. Also, in the following description, the term "wire" when used to denote a wire in the dryer section or finishing section encompasses other types of dryer section clothings such as fabrics, which are more common today than wires, and felts.

[0007] In dryer sections that comprise inverted and normal drying groups, various problems have occurred. The present invention is directed toward a resolution of these problems. For example, problems have been encountered in the runnability of the dryer section and in the threading of the web, problems arising from differences in the speeds of different wires, problems in the removal of broke especially in inverted groups, as well as problems related to the control of transverse shrinkage of the web. These problems tend to become worse as the running speed of the paper machine becomes higher. As to the problems of control of the transverse shrinkage of the web, the use of a single tier dryer section in general provides better control than a dryer section applying double felting.

[0008] With respect to prior art involved in and related to the present invention, reference is made to the following patent publications and articles published in journals:

- W. Haessner, "Trocknungstechnik und deren Entwicklung"; Das Papier 44, 10A, 1990;
- "The Valmet Sym-Run Concept", Paper Asia, May/Jun 1992;
- J. Yli-Kauppila, "Dryer Section for High Speed Paper Machines", Proceedings of the Helsinki Symposium of Alternate Methods of Pulp and Paper Drying, Helsinki June 4-7, 1991;
- Sam Palazzolo, "No-draw drying", Tappi Journal, September 1990;
- W. Leitenberger, "Die Contirun-Trockenpartie fur schnellen, sicheren Bahnlauf", Das Papier, Heft 6, 1992;
- U.S. Patent Nos. 3,753,298, 3,868,780, 4,602,439, 4,972,608, 4,982,513, 5,022,163, 5,065,529, 5,146,696, and 5,177,880;
- V. Korhonen and A. Kuhasalo, "Ropeless tail threading from press to reel", World Pulp & Paper Technology 1993;
- H. Lepisto und P. Eskelinen, "Verbesserung der Lauffahighkeit schneller Papiermaschinen mit Hilfe neuer Ventilationseinrichtungen", Das Papier 1985, Heft 10A;

- Lindberg, Juppi, Eskelinen, "High Speed Dryer Section Developments for Sheet Stability", 78th Annual Meeting, Technical Section CPPA, 1992.

[0009] With respect to the prior art closely related to the invention, reference is further made to the assignee's Finnish Patent No. 91,900 (corresponding to U.S. Patent Application Serial No. 07/808,161, the specification of which is hereby incorporated by reference herein), in which a method is described for drying a web in the dryer section of a paper machine, in particular for reducing the tendency of curling of the paper web. In the method described in FI '990, the paper web is dried on drying cylinders, against whose heated faces the paper web is pressed by means of a drying wire. In the dryer section, groups of drying cylinders are used, in which twin-wire draw and/or single-wire draw is/are applied. In this method, among other things, it has been considered inventive that in the dryer section, hot water vapor is fed substantially onto the entire width of the paper web. By means of this vapor, tensions that have been formed or that tend to be formed in the fiber mesh in the paper web are relaxed by means of heat and moisture in the area of their formation or substantially immediately thereafter.

[0010] In the prior art, a dryer section is known which is composed exclusively of the above drying groups with a single-wire draw. In these groups, between the contact-drying cylinders placed in the upper rows in the groups, normal small diameter suction rolls that are provided with inside (internal) suction boxes have been used. One particular prior art dryer section of interest is a dryer section supplied by, e.g., J.M. Voith GmbH, and situated at PM 1, Stora Feldmuehle, Reisholz, Duesseldorf, Germany which initially contained only single-tiered groups in the predryer section but later was modified to provide a double felted group as the last group in the predryer section.

[0011] A drawback of these small diameter suction rolls is the high requirement of negative pressure and suction energy because, owing to the small diameter of these rolls, high centrifugal forces arise on these rolls which tend to separate the web from the drying wire. By means of the curve sectors of small radius, the suction rolls also produce a rather large relative difference in speed between the drying wire and the web, which is in many respects unfavorable. Further drawbacks include the wear of the seals at the suction box inside the suction rolls and the repeated requirement of servicing of these seals as well as the high noise level. In this prior art paper machine, the overall concept in accordance with the present invention has not been taken into use, which concept also includes the paper finishing stages, such as surface-sizing, coating and/or calendaring.

[0012] With regard to additional prior art related to the present invention, reference is made to the assignee's Finnish Patent No. 83,441, Finnish Patent No. 91,899 (corresponding to the assignee's U.S. patent application Serial No. 08/230,059, the specification of which is hereby incorporated by reference herein), to Finnish Patent Application Nos. 934367 and 935340 (corresponding to the assignee's U.S. patent application Serial Nos. 08/213,148 and 08/229,471, respectively, the specifications of which are hereby incorporated by reference herein), to EP Patent No. 0 427 887 and U.S. Patent No. 5,269,074 assigned to Beloit Corporation. In the '074 patent, a dryer section is described whose initial part consists of a number of successive normal groups with single-wire draw and in whose final end there is one group with twin-wire draw in which the web has open draws between the rows of cylinders placed one above the other.

[0013] In the following, a condensed discussion will be made of the problems and requirements of further development that have been noticed in the prior art dryer sections, which have become known, e.g., from the above-mentioned patents and journal articles. As background, it should be ascertained that the highest web speeds in paper machines are, at present, already of an order of about 25 meters per second, but before long even the speed range of 25-40 m/s will be applied. Then, the bottle-neck of the runnability of a paper machine will increasingly consist of the dryer section, thus provoking an intensive effort to develop dryer sections capable of running at ever more increasing web running speeds.

[0014] In the inverted drying groups mentioned above, one particular problem is the removal of broke in the event of web breaks, for inverted groups are not self-cleaning by the effect of gravity. Thus, it is an object of the present invention to provide a paper machine, in particular for the manufacture of fine paper, in which inverted groups are not needed at all but which, nevertheless, meets the other requirements that are imposed.

[0015] The above problems and some other problems are emphasized further if, in single-wire groups, the prior art small-diameter suction rolls proper are used which are provided with inside suction boxes. In order to eliminate this problem, in some machines, it has been even necessary to open some group gaps and to lower the vacuum level in the suction rolls.

[0016] From operational experience, it is known that, if the paper is dried one-sidedly, the consequence is a tendency of curling of the sheet which is not a desired trait.

[0017] When paper is dried by means of normal groups with single-wire draw from the side of its bottom face and if such asymmetric drying is extended over the entire length of the forward dryer section, the drying takes place so that first the side of the bottom face of the paper web is dried, and when the drying makes progress, the drying effect is also spread to the side of the top face of the paper web. Thus, the dried paper is usually curled so that it becomes concave when seen from above.

[0018] As known in the prior art (see DE-U-9 414 963), the tendency of curling of paper is already affected in

connection with the web formation, in particular in the stage of sheet formation (see for example, the assignee's Sym-Former™ concept) by means of the discharge jet and by selection of the difference in speed of the wire as well as by means of other running parameters. As known from the prior art, for example in the case of copy paper, by means of unequalsidedness of drying in the finishing-dryer section, a suitable initial curling is regulated for the sheet in order that the curling of the paper after one-sided and two-sided copying could be optimized. In the case of copying paper, the reactivity of curling, i.e., the extent of curling produced per unit of change in moisture content, is affected to a greater extent by means of the z-directional structure, i.e., the structure in the direction of the thickness of the paper, which is produced in connection with the web formation in the wet end.

[0019] The most recent prior art related to the present invention in high-speed paper machines, in particular in fine-paper machines, has been based on dryer sections in which there is single-wire draw over the major part of the length of the dryer section and, with a view toward controlling the tendency of curling of paper, in practice, also an inverted group has always been employed in order that the drying could be made sufficiently symmetric in the z-direction. As noted above, an inverted group results in evident drawbacks in respect of the overall efficiency of the machine, as well as the runnability of the machine, and in respect of the profitability of the paper machine investment. Thus, in view of the optimization of the efficiency of a paper machine, a fully supported dryer section based on normal groups with single-wire draw, without inverted groups or groups with twin-wire draw, would be a particularly justified and advantageous embodiment. The professionals in this field have, however, not been courageous enough to develop and introduce such an embodiment because it has been considered that it would be uncontrollable and unfavorable in view of the tendency of curling of the paper.

[0020] Reference is also made to Finnish Patent Application No. 940749, corresponding to U.S. patent application Serial No. 08/389,952, the specification of which is hereby incorporated by reference herein. This application describes a dryer section which does not include any inverted dryer groups.

OBJECTS AND SUMMARY OF THE INVENTION

[0021] Accordingly, it is an object of the present invention to approach the problems discussed above from a new point of view and to suggest new and novel embodiments contrary to conventional modes of thinking for these problems.

[0022] It is another object of the present invention to provide a dry end of a paper machine with finishing equipment having a high efficiency while producing good paper quality, i.e., diminished curling of the web, due in part to the integrated unity of the dry end of the paper machine.

[0023] It is a further object of the invention to provide a dry end of a paper machine with finishing equipment in which so-called ropeless tail threading can be applied favorably over the entire length of the dryer section in the machine direction, which contributes to making the constructions simpler and machine standstill times shorter.

[0024] In view of achieving the objects stated above and others, in the method in accordance with the invention for producing surface-treated paper, in particular fine paper, comprises the following steps which are preferably carried out in the listed sequence:

a1) a paper web which has been dewatered to a first dry solids content k_1 from about 35% to about 60% by pressing is dried in a forward dryer section to a second dry solids content k_2 from about 90% to about 99%;

a2) the forward-drying in step a1) is carried out by applying drying energy to the paper web to be dried over the entire length of the forward dryer section asymmetrically in the z-direction from the side of a bottom face of the web;

a3) the step a1) is carried out by means of a number of successive groups with single-wire draw that are open downward on support of a drying wire such that shrinkage of the web both in the machine direction and in the cross direction is reduced or at least partially prevented, which shrinkage tends to take place when the dry solids content becomes higher;

b1) the paper web, which has a tendency of curling because of the asymmetric forward-drying that has taken place in steps a1)-a3), is passed to a finishing section; and

b2) the paper web is finished in the finishing section by surface treatment operations, which include surface coating/sizing which are effective to moisten the web, and/or by calendaring, i.e., supercalendering and soft calendaring, which both plastically deform or "work" the web, so that the tendency of curling that arose in the web in the forward dryer section is substantially reduced. The moistening process and the plastic deformation process, if both are utilized, are typically performed one after the other in the running direction of the web.

[0025] In one embodiment, in connection with a web break taking place in the stage a3, the removal of paper broke is carried out from underneath the drying groups that are open downward, substantially by the force of gravity onto a broke conveyor placed underneath.

[0026] The forward drying section mentioned in stage a1) is also commonly referred to as a "predryer section" or a "main dryer section". Also, in the event that the finishing section is a soft calendar, no additional dryer section is required.

[0027] The dry end of a paper machine in accordance

with the invention with its finishing equipment comprises a forward dryer section including groups with single-wire draw of a multi-cylinder dryer arranged over its entire length between the press section of the paper machine and a first finishing unit, which groups are open downward and include steam-heated drying cylinders against which the web to be dried is pressed into direct contact by a loop of a drying wire that runs above each of the groups with single-wire draw. The groups with single-wire draw include a number of reversing suction cylinders or rolls arranged inside the drying wire loop. By means of the reversing suction cylinders or rolls, the paper web is kept in contact with the drying wire by the effect of a difference in pressure and/or by means of the tightening pressure of the web when the paper web is at the side of the outside curve. The group gaps between the groups with single-wire draw are closed, or there is only a small open draw in the group gap. After the forward dryer section or as an off-line unit, a finishing section is arranged for surface-treating the dried web while it is worked plastically and/or moistened so that the tendency of curling that arose in the web in the forward dryer section are substantially eliminated.

[0028] In the concept in accordance with the invention, in which the forward-drying takes place by means of a forward dryer section comprising groups with single-wire draw without inverted groups, after the forward-drying the tendency of curling of the paper becomes obvious. However, since in the invention, a surface-sizing unit is used or the paper is coated, the paper faces are wetted, whereby expanding and, at the same time, relaxing of the paper sheet take place. When the finishing-dryer is a normal dryer with twin-wire draw in which the temperatures of the upper and lower cylinders can be regulated independently from one another, the curling can be regulated by means of the drying. Also, the curling can be affected by regulating the operation of the size press. Then, in fact, a compromise is made, for example, in respect of the symmetric size quantity because the faces are wetted in a controlled way asymmetrically so as to achieve the object of the invention.

[0029] When the web is surface-sized in a finishing stage included in the overall concept in accordance with the invention, the paper web is wetted from the sides of both of its faces, in a controlled way asymmetrically if necessary, and this results in relaxation of the tensions that produce a tendency of curling. After this stage, by means of the finishing-drying, the curling can be regulated to a minimal level. Thus, in the present invention, asymmetric moistening of the paper web can be used as an efficient parameter to control the tendency of curling of the web.

[0030] In accordance with the invention, a dry end of a paper machine with finishing equipment with an improved runnability can be accomplished. It has been possible to achieve this in particular in the manufacture of fine paper so that the problems related to uncontrollability of the tendency of curling of the paper are also substantially eliminated.

[0031] According to the basic concept of the invention, the dryer section situated after the press section of the paper machine includes, substantially over its entire length, a number of so-called normal groups with single-wire draw (e.g., the SYM-RUN™ concept), in which the paper web is constantly supported on the drying wire also on the reversing suction cylinders placed in the lower rows in the drying groups, such that transverse shrinkage of the paper web is reduced or at least partially prevented. The group gaps between the groups with single-wire draw are preferably also fully closed so that, in view of the runnability of the machine, a fully supported single-wire draw is achieved.

[0032] In a high-speed fine-paper machine in accordance with the invention, the forward dryer section comprises typically about 6-9 normal groups with single-wire draw, in which groups there are a total of about 30-40 steam-heated contact-drying cylinders and a corresponding number of reversing suction cylinders or rolls, preferably the assignee's VAC™ rolls. In addition to a fully supported forward dryer section with single-wire draw of the sort defined above, the overall concept in accordance with the invention also includes the paper finishing devices belonging to fine-paper machines, in which devices the paper is subjected to finishing in the form of surface-sizing, coating and/or to additional working in the form of calendaring. In this manner, faults of curling produced in the paper by the asymmetric drying in the z-direction taking place in the fully supported dryer section with single-wire draw can be eliminated so that a paper product that meets even high quality requirements, in particular a fine paper whose grammage is in the range of about 60 to about 150 g/m^2, can be produced with an improved efficiency. Thus, in the invention it has been realized that a two-sided drying of the web in the forward dryer section, which drying was considered to be indispensable in the prior art, is not necessary in view of the quality of the ultimate product, and not even the most advantageous embodiment in view of the runnability and overall efficiency of the paper machine.

[0033] In the coating of paper in accordance with the overall concept of the present invention, re-wetting of the faces also takes place, even if this moistening is not equally thorough as in surface-sizing. However, the faces of paper, which are most important in view of the curling, become moist, and by means of renewed drying it is possible to control the curling. The coating in itself reduces the tendency of curling, because the faces of paper receive an abundance of inert material, whose moisture expansion is substantially lower than that of the fibers. Thus, as a result of the coating, the faces of paper become passive in respect of moisture expansion, and on the other hand, the moisture expansion of both faces becomes substantially equal whereby the tendency of curling is reduced. During finishing of paper, super-calendaring or soft-calendaring produce plastic changes in the paper. When plastic deformation of the

sheet takes place during calendaring processes, the tendency of curling is affected and can be controlled by means of assymetry of calendaring. Another stage of treatment that affects the tendency of curling in connection with calendaring is pre-moistening of paper taking place by means of steam, which can be carried out in the invention unequalsidedly in respect of the faces. By regulating the unequalsidedness of the moistening with steam, it is possible to regulate the tendency of curling.

[0034] If necessary, the dryer section to be applied in the present invention may be provided with water-vapor treatment as described in the assignee's Finnish Patent No. 91,900, which treatment is intended for reducing the tendency of curling and in which treatment stresses or strains that have arisen, or tend to arise, in the fiber mesh of the paper web are relaxed by means of heat and moisture in the area of formation of the drying-induced internal stresses or strains or substantially immediately after that area. Further, by means of this water-vapor treatment, it is possible to control the transverse moisture profile of the paper web.

[0035] In a fully supported dryer section with single-wire draw in a paper machine in accordance with the invention, it is possible, if necessary, to use various arrangements in themselves known, such as the assignee's "Uno Run Blow Boxes"™, by whose means the support contact between the drying wire and the paper is promoted at least at the most critical points.

[0036] In the following, the invention will be described in detail with reference to some exemplifying embodiments of the invention illustrated schematically in the figures in the accompanying drawings. However, the invention is by no means strictly confined to the details of these embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] The following drawings are illustrative of embodiments of the invention and are not meant to limit the scope of the invention as encompassed by the claims.

[0038] Figure 1 shows a side view of a paper-machine dry end in accordance with the invention from the beginning of the forward dryer section to the machine reel-up.

[0039] Figure 2A shows the forward dryer section in the paper-machine dry end as shown in Fig. 1.

[0040] Figure 2B shows the final end of the forward dryer as shown in Figs. 1 and 2A, the surface-treatment unit, and the forward end of the finishing dryer.

[0041] Figure 2C shows a finishing dryer in a paper machine shown in Figs. 1, 2A and 2B.

[0042] Figure 2D shows a machine calender and a machine reel-up in a dryer section as shown in Figs. 1, 2A, 2B and 2C.

[0043] Figure 3 shows a two-stage coating/surface-sizing unit placed after a finishing dryer.

[0044] Figure 4 shows a gate-roll surface-sizing unit as a finishing unit wherein, differing from the preceding and the following illustrated embodiments, the web proceeds from right to left.

[0045] Figure 5 shows a second exemplifying embodiment of a two-stage coating/surface-sizing unit and of its finishing dryer.

[0046] Figure 6 shows a finishing unit that comprises a two-sided surface-sizing device and its finishing dryer.

[0047] Figure 7 shows a third exemplifying embodiment of a two-stage coating/surface-sizing unit between and after which there are groups with single-wire draw that constitute finishing dryers.

[0048] Figure 8 shows another exemplifying embodiment of a two-stage coating/surface-sizing unit such as that shown in Fig. 7 between and after which there are groups with single-wire draw that constitute finishing dryers, which are two groups with twin-wire zones.

[0049] Figure 9 shows a third exemplifying embodiment of a two-sided surface-sizing unit, of a subsequent turning air-impingement unit, and a finishing dryer.

[0050] Figure 10 shows a gate-roll surface-sizing unit as a finishing unit which is similar to Fig. 4, however in this embodiment after the gate-roll, there is a provision made for an infrared dryer unit, and the transfer into the cylinder group in the finishing dryer which is not shown in Fig. 4.

[0051] Figure 11 shows a paper-machine dry end in accordance with the invention in which the forward dryer section is followed by a soft calender before the reel-up.

[0052] Figure 11A shows the rear end of Fig. 11 on an enlarged scale.

[0053] Figure 12 shows an exemplifying embodiment of an off-line coating unit, which is applied after a forward dryer section in which there are no inverted groups, so that an overall combination that makes use of the method of the present invention is obtained. In this figure, the process sequence is from right to left.

[0054] Figure 13 shows a second exemplifying embodiment of an off-line coating unit applied in the method of the invention and of its finishing dryer.

DETAILED DESCRIPTION OF THE INVENTION

[0055] Referring to the accompanying drawings wherein like reference characters refer to the same or corresponding elements, in accordance with the embodiments shown in Figs. 1, 2A, 2B and 11, a paper web W_{in} is brought to a forward dryer section D1 from a press section (not shown) in which the web is dewatered by pressing to a dry solids content k_1 of between about 35% and 60% onto a drying wire 15 of a first dryer group R_1 with single-wire draw. The web initially adheres to the wire 15 after the press section by the effect of negative pressure in suction boxes 13 (Fig. 2A). The forward dryer section comprises 8 groups $R_1,...,R_8$ with single-wire draw and the web W has closed draws in group gaps defined between each adjacent dryer group.

[0056] In the forward dryer section D1 shown in Figs. 1 and 11, which is included in the overall concept of the

invention, there are normal groups $R_{1,...,N}$, N being from 4 to 11, preferably N is 6 to 9. All the single-wire groups $R_1,...,R_N$ are so-called normal groups in which steam-heated smooth-faced drying cylinders 10 are situated in an upper horizontal row and reversing suction cylinders 11 are situated in a lower horizontal row underneath the upper row of drying cylinders 10.

[0057] Each normal group $R_1,...,R_N$ has a separate drying wire 15 which is guided by guide rolls 18. Each drying wire 15 presses the web W to be dried on the drying cylinders 10 in the dryer group against their smooth heated faces, and on the reversing cylinders 11, the web W remains at the side of the outside curve on the outer face of the wire 15. On the reversing cylinders 11, the web W is kept reliably on support of the wire 15 against the effects of centrifugal forces by the effect of the negative pressure present in grooved faces 12 of the reversing cylinders 11 or in the perforated mantle of corresponding suction rolls, whereby transverse shrinkage of the web W is also counteracted. The reversing suction cylinders 11 that are used are particularly favorably suction cylinders marketed by the assignee under the trademark "VAC-ROLL"™, which cylinders do not have inside (internal) suction boxes and with respect to the details of whose constructions reference is made to the assignee's Finnish Patent No. 83,680 (corresponding to the assignee's U.S. Patent Nos. 5,022,163 and 5,172,491, the specifications of which are hereby incorporated by reference herein).

[0058] In a forward dryer section D1 in accordance with a preferred embodiment of the invention, the support contact between the web W and the drying wire 15 is also kept adequate on the straight runs between the drying cylinders 10 and the reversing cylinders 11 by employing blow-suction boxes 17 at least on the runs from the drying cylinders 10 to the reversing cylinders 11 (Figs. 2A and 2B). The blow-suction boxes 17 prevent the formation of pressures induced by the air that follows the wire 15 in the closing wedge-shaped nip spaces between the wire 15 and the mantle of each of the cylinders 11 as well as by air that follows the surface of the cylinders 11. Blow-suction boxes 17 are understood in the art to denote blow boxes in which the air blowing produces a negative pressure, and the boxes 17 do not communicate with sources of negative pressure. With respect to the details of the constructions of these blow-suction boxes 17, which are marketed by the assignee under the trade mark "UNO RUN BLOW BOX"™, reference is made to the assignee's Finnish Patent Nos. 59,637, 65,460 and 80,491 (corresponding to the assignee's U.S. Patent Nos. 4,441,263, 4,516,330 and 4,905,380, the specifications of which are hereby incorporated by reference herein). After the introduction of the "UNO RUN BLOW BOX"™, other embodiments of blow boxes were introduced, with respect to which reference is made to U.S. Patent No. 4,502,231 (assigned to J.M. Voith GmbH), the application of this blow box in the positions of the blow boxes 17 is also included in the scope of the overall concept of the present invention.

[0059] As shown in Figs. 2A and 2B, in the groups $R_1,...,R_N$ with single-wire draw in the forward dryer section D1, blow boxes 16 may also used in the gaps between the reversing cylinders 11, although not every gap is provided with such a blow box 16. By means of boxes 16, the intermediate spaces (gaps between the reversing cylinders) are air-conditioned and evaporation of water from the web W is promoted. The faces of the drying cylinders 10 are kept clean by suitable doctors 14.

[0060] In the forward dryer section D1 applied in the invention, it is a further advantage that broke removal by the force of gravity can be applied in the groups $R_1,...,R_N$ with single-wire draw, which extend over the entire length of the dryer section. This results from the fact that the groups $R_1,...,R_N$ with single-wire draw are open toward the bottom so that the paper web WS that becomes broke can be removed without any particular arrangements onto the broke conveyor (not shown) placed in the basement space of the paper machine, and carried on the conveyor further into a pulper or pulpers.

[0061] In Fig. 1, the overall horizontal length L of the forward dryer section D1 in the machine direction is about 80 m when eight normal groups $R_{1,...,N}$ are used (N = 8). The number N1 of the drying cylinders 10 used in each of the normal groups $R_{1,...,N}$ is in the range of from 3 to 8, preferably from 4 to 7.

[0062] With a view toward reducing transverse shrinkage of the web W, it is particularly important that, in the forward dryer section D1, the web W is kept constantly in reliable contact with the drying wires 15. This holding effect is produced on the reversing cylinders 11 by means of the negative pressure present in the grooved mantle 12 or equivalent on the outer face of reversing cylinders 11 and, on the straight draws between the cylinders 10 and the reversing cylinders 11, by means of pressure levels provided by blow-suction boxes 17, and also partly by means of a tension T of the web W in the machine direction, which produces a contact pressure $P_k = T/R$ (R = radius of the cylinders 11) between the web W and the wires 15.

[0063] As stated above, the reversing cylinders 11 that are used in the forward dryer section D1 are preferably the assignee's VAC™ rolls, in whose interior preferably a vacuum level of about 1 kPa to about 3 kPa is used. This pressure effect is spread through the perforations in the reversing cylinders 11 into the grooved mantle 12. In this manner, and in combination with the Uno-Run Blow Boxes™ 17, the wedge-shaped nip spaces between the reversing cylinders 11 and the drying wire, i.e., the closing nip, can be evacuated efficiently. Moreover, a positive pressures cannot be induced in these wedge spaces which might attempt to separate the web W from the drying wire while the web W is placed outside. If the reversing cylinders 11 in the forward dryer section D1 are suction rolls provided with inside suction boxes, the suction zone should preferably

be extended to an area wider than the turning sector of the drying wire 15 and the web, so that the suction effect and the free air flow can be extended to the wedge spaces for the purposes mentioned above.

[0064] When the forward dryer section D1 applied in the invention comprises groups $R_1,...,R_N$ with single-wire draw alone, the dryer section is open toward the bottom. This results in the substantial advantage that, in the event of a web break, the removal of paper broke WS can be carried out from underneath the drying groups $R_1,...,R_N$ open toward the bottom mainly by the force of gravity onto a broke conveyor placed underneath. Fig. 1 shows the conveyor belt 19 of the broke conveyor and its drive rolls 19a,19b. On the belt 19 of the broke conveyor, the paper broke WS is passed to a pulper 19c placed at one end of the broke conveyor.

[0065] In addition to the forward dryer section D1 described above, the overall combination in accordance with the invention and the dry end of the paper machine that makes use of the method include a finishing unit or section D2 arranged after the forward dryer section D1. The finishing unit includes a machine reel-up 50, for example a Pope-type reel-up. The machine reel that is being prepared by means of the reel-up 50 on-line is denoted with the reference MRo, and one complete machine reel with the reference MR.

[0066] As shown in Figs. 1, 2B, 2C, and 2D, after the forward dryer section D1, the paper web Wk, which has been dried to a dry solids content of k_2 from about 96% to about 99%, is passed over paper guide rolls 25 and across a measurement beam 26, which measures the property profiles of the paper and is placed between guide rolls 25, to a coating device 20 which constitutes a part of the finishing section D2. Coating device 20 is, for example, a coating device marketed by the assignee under the name Sym-Sizer™. The coating device 20 includes two opposite applicator rolls 21 and 22, in connection with both of which there is a size feed device 23 and 24 so that the paper web Wk is coated from both sides in a coating nip NS formed between the rolls 21 and 22 to thus constitute a finishing operation conducted in the finishing section D2. Owing to the water-containing coating agent, the web W_k is moistened from both sides in the coating nip. Then, the web, which was dried in the forward dryer section D1 asymmetrically from the side of its bottom face W_a and which has a tendency of curling, is treated to such a condition that its internal strains are primarily relaxed or are at least substantially reduced.

[0067] As shown in Fig. 2B, the web W_p that has been moistened and coated from both sides is passed to the finishing section D2. As shown in Figs. 1 and 2C, an "afterdryer" or finishing-dryer unit of the finishing section comprises two wire groups R_{21} and R_{22}. Of these, the first group R_{21} is a group with single-wire draw, and the group R_{22} is a group with twin-wire draw. After the coating device 20, a first lower cylinder 30' is a drying cylinder whose face is coated so that adhering of the web W_p to the face is prevented, such as with the assignee's "Release Mate"™ coating (Fig. 2C). In the upper row of the group R_{21}, there are steam-heated drying cylinders 30, and in the lower row there are reversing suction cylinders 31, for example the assignee's Vac rolls, which have grooved faces 32 subjected to a vacuum from the interior.

[0068] The drying wire 35 of the group R_{21} carries the web W_p as a closed draw to the next twin-wire group R_{22}, owing to which, the web moistened in the coating device 20, can be dried symmetrically from both sides without a tendency of curling.

[0069] As further shown in Fig. 2C, the group R_{22} with twin-wire draw comprises two horizontal rows of steam-heated drying cylinders 30A and 30B, between which the web has free draws W_0. The group R_{22} includes an upper wire 35A which is guided by guide rolls 38 and by guide rolls 39 arranged in gaps between the upper cylinders 30A. Similarly, the group R_{22} includes a lower wire 35B which is guided by the guide rolls 38 and by the guide rolls 39 arranged in gaps between the lower cylinders 30B.

[0070] Also, as shown in the embodiment in Fig. 2C, at the vicinity of the wire guide rolls 39, at the inlet side of the web W and of the drying wire 35A and 35B, air-blow boxes 37 are used. Out of the blow boxes 37, which are arranged in gaps between the drying cylinders 30A, 30B, controlled air jets having a suitable direction and blow velocity are applied to the vicinity of the runs of the drying wires 35A,35B placed at their proximity and to the vicinity of the free sectors of the wire guide rolls 39. By means of the air jets, the support contact between the drying wires 35A,35B and the web W is promoted, formation of detrimental differences in pressure and fluttering of the web W on the free draws W_0 are counteracted. These blowings can also be applied through the drying wires 35A,35B, whereby it is possible to promote the ventilation of the pocket spaces P formed in the gaps between the drying cylinders 30A,30B.

[0071] In the twin-wire group R_{22} as shown in Fig. 2C, it is also possible to employ the draw arrangement marketed by the assignee under the trade mark "TWIN-RUN"™, in which the guide rolls 39 are placed so that the drying wires 35A and 35B accompany the web from one of the drying cylinders 30A and 30B onto the next drying cylinder so that the free draws W_0 of the web W can be made shorter, as compared with free draws of full length. With respect to the further details of the "TWIN-RUN"™ concept and of the blow boxes 37, reference is made to the assignee's Finnish Patent No. 80,103 (corresponding to DE Patent No. 3,818,600).

[0072] A regulation parameter that can be utilized in the invention and by whose means the symmetry of the drying of the opposite sides of the web W can be controlled is the tensions T_A and T_B of the drying wires 35A, 35B in the group R_{22} shown in Fig. 2C. In a preferred embodiment of the invention, T_A and T_B are selected in a range from about 1.5 to about 8 kN/m, preferably in a

range from about 2 to about 5 kN/m. It is also possible to use an arrangement of tension of the drying wires 15 in which, also in a normal group $R_1,...,R_N$. The tension Tn of the wires 15 may be increased constantly as the drying makes progress, in accordance with the principles that are described in the assignee's Finnish Patent No. 83,441.

[0073] Moreover, the wire tensions T_A and T_B of the lower and upper wires 35A and 35B in the single twin-wire group R_{22} or groups can be selected to be different from one another if the symmetry of the drying of the web W and the objectives of the invention require that. An embodiment is particularly advantageous in which the tension T_B of the wire 35B of the lower cylinders 30B is higher than the tension T_A of the upper wire 35A. As such, the symmetry of drying is promoted by in the single twin-wire group R_{22} drying the upper side W_y of the web W to a greater extent. The symmetry of drying can also be promoted by in the twin-wire group R_{22} using different steam pressures and cylinder-face temperatures in the upper cylinders 30A as compared with the lower cylinders 30B. Preferably, in the lower cylinders 30B, a higher steam pressure and cylinder-face temperature are employed than in the upper cylinders 30A, whereby, together with the difference in tension ($T_B > T_A$) between the wires 35A and 35B, the symmetry of the drying of the web W is promoted further by drying the upper face W_y of the web W in the single twin-wire group R_{22} to a greater extent than the lower face Wa, whose drying proportion was, in the normal groups $R_1,...,R_N$ in the forward dryer section D1, owing to the cylinders 10, higher than the drying of the upper face W_y. Moreover, the above asymmetry of drying can be controlled by selecting the permeabilities of the upper wire 35A and the lower wire 35B to be different.

[0074] The various means, described above with regard to the twin-wire group R_{22}, for regulating the symmetry of the drying of the opposite sides W_a and W_y of a surface-sized and/or coated web, which may be calendared if necessary, and, if necessary, for regulating an asymmetry of drying controlled in view of the objectives of the invention, can also be used in the twin-wire groups R_{61} (Fig. 6), R_{91} and R_{92} (Fig. 8), and R_{101} (Fig. 9) which will be described below.

[0075] The web W_{pk} which has been dried in the finishing section D2 to some extent asymmetrically, is passed to the next finishing unit, which is a calender 40. A calendaring nip NC in the calender 40 is formed between calender rolls 41 and 42 supported on a frame 43. The lower roll 42 is an adjustable-crown roll in view of regulation of the nip pressure in the calendaring nip NC. The coated and calendared web W_{pkc} is passed over a paper guide roll 38c and across a measurement beam 45 to the machine reel-up 50 which is, for example, a Pope-type reel-up, by whose means a machine reel MR_o is formed out of the web W_{pkc} as shown in Fig. 2D. The complete machine reel is denoted by reference MR. As described above, in the finishing unit D2, the web is dried from the sides of both of its faces W_a and W_y so that the drying is sufficiently symmetric in the z-direction to compensate for any faults of curling that have arisen in the forward dryer section D1 and to prevent formation of any further faults.

[0076] In the finishing sections described above, the ratio of the proportions of moistening of the opposite sides W_a and W_y of the web W and/or the ratio of the proportions of drying of the opposite sides W_a and W_y of the web W and/or the relative sequence of these factors is/are regulated so that the tendency of curling that has arisen in the forward dryer section D1 can be eliminated to an extent that is necessary in view of the quality and the purpose of use of the paper that is manufactured. The finishing sections D2 described above and those that will be described in the following provide for a number of different and alternative possibilities for regulation of the finishing proportions of the moistening, coating and/or finishing drying of the opposite sides W_a and W_y of the web W. The type of finishing section D2 that is selected depends on the quality of the paper produced and on the different running parameters of the machine. As to the coating of the web W, it should be stated that the coating agents are materials inert in respect of the tendency of curling, so that they in themselves already contribute to a possibility of controlling and reducing the tendency of curling. Asymmetric web W coatings can also be used.

[0077] In some of the illustrated embodiments described above, a frame construction 100 of the paper machine has also been sketched. As shown in Fig. 1, underneath the finishing section D2, there is a broke conveyor 19,19a,19b which carries the broke likewise to the pulper 19c. In the finishing section D2, one group R_{22} with twin-wire draw is also shown, which is provided with a lower wire 35B, so that this group is not open toward the bottom. In the area of the group R_{22}, owing to the group R_{21} with single-wire draw, the web is already so dry that, in the area of this group R_{22}, there is no substantial risk of breaks, which breaks would lower the overall efficiency of the paper machine.

[0078] Fig. 3 shows an exemplifying embodiment of a two-stage coating/surface-sizing unit which is provided with the assignee's Sym-Sizer™ device. A paper web Wout is brought from the forward dryer section D1 wherein it is asymmetrically dried and thus having a tendency of curling. The paper web Wout is passed through a calender 40A having a nip NC in which the paper web is worked so that the tendency of curling is reduced. After this, the paper web W_k is passed into a first coating station 60A which comprises a coating unit 20A defined by coater rolls 21 and 22. In connection with the lower roll 21, there is a coating-agent applicator device 23, so that an upper face W_y of the web W_k (oriented downward in the coating unit 20A, is coated with the coating agent while it may be, at the same time, moistened to a significant extent. The coating station 60A includes infrared dryers 61a and 61b, by whose means the moistened

web face W_y is primarily dried free of contact. After that, in the unit 60A, an air-impingement dryer unit 62 is arranged, in which the web W_k is dried further free of contact primarily from the side of its moistened face W_y. Thereafter, the web W_k is passed over a cylinder 63 to a first group R31 of finishing-drying cylinders. The face of the cylinder 63 is coated with some coating that prevents adhesion of the web, such as, for example, the assignee's "Release Mate"™ coating. The group R31 is a group with single-wire draw in itself known, in which there are steam-heated drying cylinders 10a in an upper row and Vac suction cylinders 11a in a lower row as well as an upper drying wire 15a. On the cylinders 10a, the web W_k is dried from the side of its lower face Wa, i.e. from the side opposite to that dried in the unit 60A and previously coated. In this manner, a symmetric drying is ensured.

[0079] The finishing unit D2 comprises a second coating station 20B which is arranged after the group R_{31} with single-wire draw and which comprises a pair of coater rolls 21 and 22. Of these rolls, in connection with the lower roll 22, there is a coating-agent applicator device 24, so that the web W_{p1}, whose upper face has been coated, is also coated from the side of its lower face Wa, whereby the web may be, at the same time, again moistened. After this, a second drying unit 60B follows, which comprises infrared units 61a and 61b which dry the web from the side of the lower face Wa, and an air-impingement unit 62. The unit 60B is followed by a second short group R_{32} with single-wire draw, in which there are drying cylinders 10b in an upper row and reversing suction cylinders 11b in a lower row and in which there is an upper drying wire 15b. From the group R_{32}, a web W_{p2} is received which has been coated from both sides and dried in a purposeful manner in view of compensating for the tendency of curling of the web since the moistening of the web via the coating process reduces its internal stresses and thus also the tendencies of curling. Thereafter, the web W_{p2} is passed to the machine reel-up 50 (Fig. 1).

[0080] Fig. 4 shows a gate-roll surface-sizing unit 120 as the first finishing unit after the last group R_N with single-wire draw in the forward dryer section, to which unit 120 the web W_k is passed over paper guide rolls 25 and 25a and across the measurement beam 26. In Fig. 4, it should be noted that, differing from the preceding and the following figures, the web arrives from the right. By means of a pair of rolls 121 and 122 in the gate-roll surface-sizing unit 120, the web W_k is surface-sized, whereby it is moistened significantly from both sides. Thus, the tendencies of curling arising from the asymmetric drying in the forward dryer section D1 are prevented. The paper web W_p that has been coated from both sides is passed over the paper guide roll 25b into the single-wire group R41 in the finishing dryer section D2, in which group the first drying cylinders 10_{CRT} have been coated, e.g., with chromium-teflon so as to prevent adhesion of the moist web W_p. After the single-wire group R_{41}, the finishing dryer and the other finishing devices can be similar to those illustrated in the preceding or following figures, being arranged in such a way that, in the finishing dryer section D2, the web is dried from the sides of both of its faces W_a and W_y, so that the drying is sufficiently symmetric in the z-direction to compensate for any curling flaws that have already arisen in the paper and to prevent further formation of such curling faults.

[0081] Fig. 5 shows an alternative embodiment of a two-stage coating/surface-sizing unit as shown in Fig. 3. The finishing section D2 shown in Fig. 5 is in other respects similar to that described above except that the group R_{51} with single-wire draw arranged between the units 60A and 60B is considerably shorter than the corresponding group R_{31} in Fig. 3. The group R_{51} comprises two steam-heated cylinders 10a as upper cylinders, and the group comprises a "Release Mate"™ cylinder 63 as the first lower cylinder, as well as two reversing cylinders 11c. In the manner described above, the group R_{51} is followed by the other coating station 20B and its dryer unit 60B. Then, there follows the second group R_{52} with single-wire draw, which is similar to the group R_{51} with single-wire draw and which has an upper drying wire 15d, upper drying cylinders 10d, and lower reversing cylinders 11d.

[0082] In the embodiment shown in Fig. 5, and also in some other preceding illustrated embodiments, a paper-tail cutting device 27 is shown by whose means the paper tail is cut from one edge of the web W, to be widened finally to a web of full width in a manner in itself known.

[0083] In the invention, it is advantageously possible to apply ropeless tail threading because of the forward dryer D1 that comprises groups $R_1,...,R_N$ with single-wire draw and of the finishing section D2 that is arranged appropriately.

[0084] Fig. 6 shows a finishing section D2 which includes a double-sided surface-sizing unit 20. This unit 20 is similar to that described above in relation to Fig. 2B. In the unit 20, the web W_k is coated and moistened from both sides so that the web W_p passing to the finishing dryer is moistened from both sides and the strains that produce a tendency of curling in the web are substantially relaxed. The finishing dryer shown in Fig. 6 differs from that shown in Fig. 2B in the respect that, in Fig. 6, there is just one finishing dryer group R_{61} in whose initial part, a single-wire draw is applied by means of an upper wire 35A and drying cylinders 30A' and 30B'. In the final end of the group R_{61}, a twin-wire draw is applied in the manner described above by means of the wires 35A and 35B. With regard to the twin-wire draw, the arrangement of equipment and the performance of the drying are similar to those described above with regard to the group R_{22} in Fig. 2C. In the beginning of the group R_{61} as shown in Fig. 6, first, there is a lower drying cylinder 30' which has been coated in the manner described above, and after that there is a

corresponding upper drying cylinder 30A', after which the draw of the upper wire 35A starts under the cylinder 30B'. This is followed by the twin-wire draw similar to that described above and accomplished by means of the upper and lower wires 35A and 35B. Thus, after the coating, a symmetrically dried web W_{pk} is obtained which has no tendency of curling.

[0085] Fig. 7 shows a modification of the finishing section D2 as shown in Fig. 3 which is in other respects similar to that shown in Fig. 3 except that the drying units 60A and 60B placed after the coating units 20A and 20B have been accomplished in a different manner. As shown in Fig. 7, the web Wout is brought from the forward dryer section D1 in accordance with the invention and passed into the calender 40A through the calendaring nip NC to the coating unit 20A, where the upper face W_y of the web is coated, whereby it is moistened to a significant extent. After that, the web is passed into a combination dryer 60A, which comprises initially an infrared unit 61A and thereupon an airborne unit 62A, in which the drying effect is concentrated on the moistened top side W_y of the web. Thereafter, a group R_{81} with single-wire draw is arranged which is similar to that shown in Fig. 3. In the group R_{81}, the web is dried on the drying cylinders 10a mainly from the side of its lower face Wa. After the group R_{81}, a second coating unit 20B is arranged in which the web is coated and moistened from the side of its lower face Wa. Thereafter, a second combination dryer 60B is arranged in which there is first an infrared unit 61B and then an airborne unit 62B in which the web drying effect is concentrated on the upper face W_y of the web. This is followed by a further group R_{82} with single-wire draw which is similar to that shown in Fig. 3. In this group R_{82}, the drying effect is concentrated on the lower face W_a of the web. Thus, a web W_{p2} is produced that has been coated from both sides and dried symmetrically and thus its tendency of curling has been reduced or at least partly prevented.

[0086] Relative portions of drying taking place in the infrared drying unit(s) 61A,61B, in the air-impingement dryer or airborne unit(s) 62A,62B and in cylinder sections associated therewith R_{81} and R_{82} can be varied as required or desired to provide optimum conditions.

[0087] Fig. 8 illustrates double-sided coating as shown in Fig. 7 in the finishing unit D2, which is in other respects similar to that shown in Fig. 7, except that the finishing-drying groups R_{91} and R_{92} of Fig. 8 differ from the corresponding groups R81 and R82 shown in Fig. 7. The first group R_{91} shown in Fig. 8, placed after the first combination dryer 60A, is similar to the group R_{61} shown in Fig. 6, so that in its initial end there are two coated drying cylinders 30' and 30". After drying cylinders 30' and 30", a lower reversing cylinder 30B' is arranged, after which the twin-wire draw starts, which is accomplished by means of the upper and lower wires 35A and 35B and in which the web is dried from the sides of both of its faces W_y and Wa. After the group R_{91}, a second coating unit 20B is arranged which is similar to that described in Fig. 7 and in which the web is coated and moistened from the side of its lower face Wa. Thereafter, a combination dryer 60B similar to that described above is arranged. The last group R_{92} is in other respects similar to the group R_{91} described above, the only difference being that the lower cylinder 30' is missing and that the group R_{92} has one pair fewer heated drying cylinders 30A. From the finishing section D2 as shown in Fig. 8, a web W_{p2} is obtained that has been coated double-sidedly and that has been dried so that it has no tendency of curling.

[0088] Fig. 9 shows a modification of a finishing section D2 which essentially resembles that shown in Fig. 6 and which is in other respects similar to Fig. 6 except that the web W_p that has been coated double-sidedly in the coating unit 20 is passed after the coating nip NS as a downward inclined run to a reversing airborne unit or turning airborne unit 70. By means of the contact-free guidance provided by the reversing airborne unit 70, the run of the web is turned from having been downwardly inclined, through about 50° to about 70°, to become upwardly inclined. The unit 70 performs the turning of the moist web free of contact and, to some extent, also applies a drying effect to the upper face of the web.

[0089] After the unit 70, the web W is passed in the upwardly inclined straight run through the combination dryer 60, in which there is first an infrared unit 61 and after that a contact-free airborne unit 62. After the combination dryer 60, the web W_p is passed to the twin-wire unit R_{101}, in whose initial end there is a short portion with single-wire draw, which comprises a coated upper cylinder 30A' and a non-coated reversing cylinder 30B'. After the initial end, the body of group R_{101} with twin-wire draw is arranged, which is similar to that described above and which has been accomplished by means of the upper and lower wires 35A and 35B and by means of the drying cylinders 30A and 30B. From the group R_{101}, a web W_{p2} is obtained which has been coated double-sidedly and which has no detrimental tendency of curling, in spite of the asymmetric drying that was carried out in the forward dryer section D1.

[0090] Fig. 10 shows such a modification of the finishing section D2 as shown in Fig. 4 in which the web Wout is passed over the paper guide roll 25 and through a measurement beam 26 to a gate-roll coating unit 120 similar to that shown in Fig. 4, in whose coating nip NS the web W_k is moistened and coated from both sides. The transfer of the coated web W_p after the gate-roll unit 120, as shown in Fig. 10, differs from Fig. 4 in the respect that the web W_p is passed through a reversing airborne unit 70 (also referred to as a turning airborne unit), which turns and carries the web free of contact and in which the downwardly inclined run of the web is turned through about 60° to become an upwardly inclined run. On the upwardly inclined run of the web, an infrared dryer unit 60C is arranged to operate, in which a lower unit 61C dries the web from the side of its lower face W_a and a upper unit 61D dries the web from the side of its upper

face W_y. After this, the web is passed to the group R_{102} with single-wire draw, which is similar to that described above.

[0091] Figs. 11 and 11A are illustrations similar to Fig. 1 of a combination of a forward dryer section D1 and a finishing section D2 in accordance with the invention in which the finishing section comprises a soft calender 40S alone. If necessary, as the calender, it is also possible to use two or more soft calender units placed one after the other. As shown in Fig. 11A, the soft calender 40S comprises two soft-calender units 41S and 42S placed one after the other. In the calendaring nips NC_1 and NC_2 in the soft calender 40S, the web is worked by the effects of heat and compression pressure and, if necessary, friction, so that the drying strains that arose in the forward dryer section D1 because of the asymmetric drying of the web and the resulting tendencies of curling are relaxed during the working to an extent sufficient in view of the purpose of use of the calendared uncoated paper.

[0092] Furthermore, as shown in Figs. 11 and 11A, underneath the reversing cylinders 11 in the last wire group R_8, a steam box 45S is arranged, in whose treatment gap the web that is placed at the side of the outside curve can be steam-treated and, thus, strains that cause curling can be relaxed. Also, a steam box 43S is arranged before the first calendaring nip NC_1 by whose means the upper face of the web W can be steam-treated. Similarly, a lower steam box 44S is arranged before the second calendaring nip NC_2 by whose means the lower face of the web can be steam-treated. By means of the steam-treatment, the tendency of curling can be reduced.

[0093] After the calender 40S or corresponding calenders, the web is passed to the machine reel-up 50. The reel that is being formed in the reel-up is denoted by reference MR_o, and the complete machine reel is denoted by reference MR.

[0094] In Figs. 3-11, a number of different variations have been illustrated by whose means the relative proportions of the moistening and/or plastic working of the different sides of the web W to be coated/calendared can be set and controlled in order to eliminate and/or to compensate for the tendency of curling of the web W that has arisen in the forward dryer section D1. Generally, the coating materials are materials that are inert in themselves in respect of the tendency of curling, so that they as such reduce the tendency of curling remaining in the base paper.

[0095] In Fig. 12, as a finishing section D20, such an off-line coating unit is shown as can be used in connection with a forward dryer section D1, in which, in accordance with the invention, the web has been dried from the side of its lower face W_a only asymmetrically in the groups $R_1,...,R_N$ with single-wire draw. The web coming from such a forward dryer section D1 can be passed through a calender 40 or even without calendaring to the machine reel-up 50. The machine reels MR obtained from the reel-up, whose paper has a tendency of curling because of the asymmetric drying described above, are passed in a subsequent off-line treatment stage to the finishing section D20 as shown in Fig. 12.

[0096] With regard to the embodiment shown in Fig. 12, it should be noted that the process proceeds in the direction of the arrow A from right to left. After the unwind stand 80a, the paper web is passed to the coating unit 81a which is followed by an infrared dryer unit 84a and, after that, by three successive airborne dryer units 85a. Thereafter, the web is passed through a cylinder dryer unit 82a to the next coating unit 81b, in which the opposite side of the web is coated. This is followed by an infrared dryer unit 84b, and after that by three successive airborne dryer units 85b, after which the web is passed to the second cylinder dryer unit 82b. When the process makes progress, there follows a third coating unit 81c and, after it, an infrared dryer unit 84c, which is followed by three successive airborne dryer units 85c and a third drying-cylinder unit 82c. After the last-mentioned unit, in the process, there is a fourth coating unit 81d, which is followed by an infrared unit 84d and by three successive airborne dryer units 85d. After airborne dryers 85d, an infrared unit 84d and a fourth drying-cylinder unit 82d are arranged. Thereafter, the web is passed to the reel-up 90 from which the coated reels MR_p are transferred to the unwind stand of the supercalender 80. The reels MR_p are calendared in the supercalender 80, and from the outlet side of the supercalender 80 the supercalendered reels MR_C are obtained.

[0097] Fig. 13 shows an alternative embodiment of a finishing section D21, which comprises an off-line coating unit and its dryer section. The paper reels MR which have been dried and reeled by means of the forward dryer section D1 described above and whose paper has a tendency of curling are unwound by means of the unwind stand 90a and then passed into the coating unit 91A, in which one side of the web is coated, whereby it becomes moistened at the same time.

[0098] After coating unit 91A, the first infrared dryer unit 92a is arranged after which the web is passed through three successive airborne dryer units 93a to the first cylinder dryer 94a, which is an inverted cylinder group provided with single-wire draw. After the inverted cylinder group provided with single-wire draw, there follows the coating unit 91b for the opposite side of the web, in which unit the opposite side of the web is moistened. After this, the web that has been moistened and that has been coated from both sides is passed to the first infrared dryer unit 92b, after which there are three successive airborne dryer units 93b and a second infrared dryer unit 92d. After the second infrared dryer unit 92d, the web is passed to the second cylinder dryer unit 94b, which is a group of drying cylinders provided with single-wire draw, in which the contact-drying cylinders are situated in the upper row and the reversing suction cylinders are situated in the lower row. After this, the

web that has been coated and dried from both sides is passed to the reel-up 96, from which machine reels MR_p are obtained whose paper has been dried and coated from both sides and has no tendency of curling. The machine reels MR_p thus produced are passed to a supercalender 80 similar to that shown in Fig. 12. Thus, in spite of the asymmetric drying that took place in the forward dryer section D1, it is possible to produce paper that has no detrimental tendency of curling.

[0099] The examples provided above are not meant to be exclusive. Many other variations of the present invention would be obvious to those skilled in the art, and are contemplated to be within the scope of the appended claims.

[0100] A method for producing surface-treated paper, in particular of fine paper, and a dry end of a paper machine that makes use of the method. A paper web that has been dewatered by pressing is dried in the forward dryer section, in which drying energy is applied to the paper web over the entire length of the forward dryer section asymmetrically in the z-direction from the side of the bottom face of the web. This step is carried out by a number of successive groups with single-wire draw that are open downward. In this manner, shrinkage of the web both in the machine direction and in the cross direction is reduced or at least partially prevented, which shrinkage tends to take place when the dry solids content becomes higher. Paper broke is removed from underneath the drying groups that are open downward substantially by the force of gravity onto the broke conveyor placed underneath. The paper web which has a tendency of curling because of the asymmetric forward-drying is passed to the finishing section where it is finished while it is moistened and/or worked plastically so that the tendencies of curling that arose in the web in the forward drying stage are substantially reduced.

Claims

1. A method for producing surface-treated paper from a paper web which has been dewatered by pressing to substantially a first dry solids content of from about 35% to about 60%, said method comprising the steps of:

   a1) drying the web (W) in a forward dryer section (D1) to substantially a second dry solids content of between 90% and 99%;
   a2) wherein the drying of the web in step al comprises the step of applying drying energy to the web over substantially the entire length (L) of the forward dryer section (D1) asymmetrically in the z-direction from one side (W_a) of the web (W);
   a3) wherein the drying energy is applied asymmetrically to the web in step a2 by passing the web (W) through a plurality of successive drying groups (R_1 to R_8) with single-wire draw that are open downward, such that the web (W) has a tendency of curling as a result of the asymmetric drying thereof in the forward dryer section (D1);

   said method being characterized by the steps of:

   b1) passing the web (W) from the forward dryer section (D1) to a finishing section (D2, D20, D21) which comprises at least one of a surface sizing device, a pigmenting device and a coating device (20, 20A, 120), said finishing section (D2, D20, D21) furthermore comprising a finishing-dryer unit arranged downstream of said device or devices; and
   b2) moistening the web (W) in the finishing section (D2, D20, D21) by means of said surface sizing device and/or said pigmenting device and/or said coating device (20, 20A, 120) such that the curling tendency of the web (W) that arose in the forward dryer section (D1) is substantially reduced.

2. The method of claim 1, wherein the web (W) is worked plastically in the finishing section (D2) by means of a machine calender (40, 40A).

3. The method of claim 1 or 2, further comprising the step of removing paper broke from underneath the drying groups (R_1 to R_8) that are open downward substantially by the force of gravity.

4. The method according to one of claims 1 to 3, further comprising carrying out steps a1, a2, a3, b1 and b2 on-line in a continuous run of the web.

5. The method according to one of claims 1 to 3, further comprising the steps of passing the web (W) to a machine reel-up after the forward dryer section (D1), and carrying out steps b1 and b2 as off-machine steps after the web has been reeled up and then unwound.

6. The method according to one of claims 1 to 5, wherein the finishing of the web at steps b1 and b2 comprises the steps of moistening both sides of the web (W) and then drying both sides of the moistened web to substantially reduce the curling tendency that arose in the web in the forward dryer section.

7. The method according to one of claims 1 to 6, further comprising the steps of:

   passing the web (W) in the finishing section (D2) through a double-sided coating device

(20),
coating and moistening both sides of the web (W) in said coating device (20),
passing the web (W) from said coating device (20) to and through said finishing-dryer unit, and
passing the web from said finishing-dryer unit (R_{21}, R_{22}) to and through a machine calender (40) and then passing the web from said machine calender (40) to a machine reel-up (50), or
passing the web (W) from said finishing-dryer unit (R_{21}, R_{22}) directly to a machine reel-up (50).

8. The method according to one of claims 1 to 6, wherein the finishing of the web at steps b1 and b2 comprises the steps of

moistening and coating only a first side (W_y) of the web (W_k) and passing the web through said finishing-dryer unit, and then
moistening and coating a second side (W_a) of the web opposite said first side and passing the web through an additional finishing-dryer unit.

9. The method according to one of claims 1 to 7, wherein the finishing of the web at steps b1 and b2 comprises the steps of

moistening the web (W) in the finishing section (D2),
passing the moistened web through at least one group (R_{22}) with twin-wire draw of said finishing-dryer unit,
applying a drying effect in the twin-wire draw group (R_{22}) to both faces (W_a, W_y) of the moistened web, and
controlling the proportion of the drying effect applied to each of the faces (W_a,W_y) of the web by regulating the ratio of the surface temperatures of drying cylinders (30A, 30B) in the twin-wire draw group (R_{22}) and/or the ratio of the tensions of a pair of drying wires (35A, 35B) in the twin-wire draw group (R_{22}).

10. The method according to one of claims 1 to 9, further comprising the step of controlling the curling tendency of the web (W) by directing hot water vapor at the web from at least one steam box (435, 445, 455).

11. The method according to one of claims 1 to 10, further comprising the step of arranging at least one infrared dryer, at least one contact-free airborne web dryers and/or a combination dryer in the finishing section (D2, D20, D21) to dry the web.

12. A dry end of a paper machine for producing surface-treated paper, comprising a forward dryer section (D1) arranged to receive a paper web (W) from a press section and a finishing section (D2, D20, D21) arranged to receive the web (W) from said forward dryer section (D1),

said forward dryer section (DI) being, over its entire length (L), composed of dryer groups (R_1 to R_8) with single-wire draw, each of said groups (R_1 to R_8) being open downward and comprising steam-heated drying cylinders (10), a drying wire (15) for carrying the web (W) and pressing the web into direct contact with said drying cylinders (10), and reversing suction cylinders (11) arranged in a loop of said drying wire (15),
characterized in that said finishing section (D2, D20, D21) comprises at least one of a surface sizing device, a pigmenting device and a coating device (20) and furthermore comprises a finishing-dryer unit arranged downstream of said device or devices, wherein said finishing section (D2, D20, D22) moistens the web (W) by means of said surface sizing device and/or said pigmenting device and/or said coating device (20, 20A, 120) such that a curling tendency of the web (W) that arises in said forward dryer section (D1) is substantially reduced.

13. The dry end of claim 12, wherein said finishing section (D2) comprises at least one machine calender (40, 40A) for plastically working the web (W).

14. The dry end of claim 13, wherein said at least one machine calender (40, 40A) is a soft calender.

15. The dry end according to one of claims 12 to 14, wherein said finishing section (D2) is an on-line process line connected with said forward dryer section (D1) and comprises a machine reel-up (50) at a final end of said process line.

16. The dry end according to claim 12 or 14, wherein said finishing section (D20, D21) is an off-line unit separated from said forward dryer section (D1).

17. The dry end according to one of claims 12 to 16, wherein said finishing-dryer unit comprises at least one group with (R_{22}) with twin-wire draw including control means arranged in connection therewith for controlling the relative proportions of the drying effects applied to the faces (W_a, W_y) of the web.

18. The dry end according to one of claims 12 to 17, wherein said finishing section (D2, D20, D21) comprises at least one infrared dryer unit, at least one airborne web dryer unit and/or at least one infrared

airborne unit.

19. The dry end according to one of claims 12 to 18, further comprising

    a broke conveyor (19, 19a, 19b) arranged at least underneath and to extend the entire length of said forward dryer section (D1), said broke conveyor receiving paper broke (WS) produced in said dryer groups (R_1 to R_8) with single-wire draw, and
    a pulper (19c) into which said broke conveyor conveys the paper broke.

20. The dry end of claim 19, wherein said broke conveyor (19,19a,19b) extends over at least a part of the length of said finishing section (D2).

Patentansprüche

1. Verfahren zur Herstellung von oberflächenbehandeltem Papier aus einer Papierbahn, die entwässert worden ist durch ein Pressen auf im wesentlichen einen ersten Trockenfeststoffanteil von etwa 35% bis etwa 60%, wobei das Verfahren die Schritte aufweist:

    a1) Trocknen der Bahn (W) in einer Vorwärtstrocknerpartie (D1) bis im wesentlichen auf einen zweiten Trockenfeststoffanteil zwischen 90% und 99%;
    a2) wobei die Trocknung der Bahn in Schritt a1 den Schritt aufweist zur Ausübung von Trocknungsenergie auf die Bahn über im wesentlichen die gesamte Länge (L) der Vorwärtstrocknerpartie (D1) asymmetrisch in der z-Richtung ausgehend von einer Seite (W_a) der Bahn (W) ;
    a3) wobei in Schritt a2 die Trocknungsenergie asymmetrisch auf die Bahn ausgeübt wird, indem die Bahn (W) durch eine Vielzahl von aufeinanderfolgenden Trocknungsgruppen (R_1 bis R_8) mit nach unten offener Einzelsiebführung geleitet wird, so dass die Bahn (W) als ein Ergebnis ihrer asymmetrischen Trocknung in der Vorwärtstrocknerpartie (D1) eine Einrolltendenz hat; wobei

    das Verfahren **gekennzeichnet ist durch** die Schritte:

    b1) Leiten der Bahn (W) von der Vorwärtstrocknerpartie (D1) zu einer Endbearbeitungspartie (D2, D20, D21), die zumindest eine Oberflächenleimungsvorrichtung, eine Pigmentiervorrichtung oder eine Beschichtungsvorrichtung (20, 20A, 120) aufweist, wobei die Endbearbeitungspartie (D2, D20, D21) ferner eine Endbearbeitungstrocknereinheit hat, die stromab der Vorrichtung oder Vorrichtungen eingerichtet ist; und
    b2) Befeuchten der Bahn (W) in der Endbearbeitungspartie (D2, D20, D21) mit Hilfe der Oberflächenleimungsvorrichtung und/oder der Pigmentiervorrichtung und/oder der Beschichtungsvorrichtung (20, 20A, 120) , so dass die Einrolltendenz der Bahn (W), die in der Vorwärtstrocknerpartie (D1) entsteht, wesentlich reduziert ist.

2. Verfahren nach Anspruch 1, wobei die Bahn (W) in der Endbearbeitungspartie (D2) mit Hilfe eines Maschinenkalanders (40, 40A) plastisch bearbeitet wird.

3. Verfahren nach Anspruch 1 oder 2, ferner mit dem Schritt zur Entfernung von Papierfertigungsausschuss von unterhalb der nach unten geöffneten Trocknungsgruppen (R_1 bis R_8), und zwar im wesentlichen durch die Schwerkraft.

4. Verfahren nach einem der Ansprüche 1 bis 3, wobei ferner die Schritte a1, a2, a3, b1 und b2 in einem kontinuierlichen Verlauf der Bahn online durchgeführt werden.

5. Verfahren nach einem der Ansprüche 1 bis 3, ferner mit den Schritten:

    Leiten der Bahn (W) zu einem Maschinenaufroller nach der Vorwärtstrocknerpartie (D1) und Durchführen der Schritte b1 und b2 als von der Maschine abgetrennte Schritte, nachdem die Bahn aufgerollt worden ist und anschließend abgewickelt worden ist.

6. Verfahren nach einem der Ansprüche 1 bis 5, wobei die Endbearbeitung der Bahn in den Schritten b1 und b2 die Schritte zum Befeuchten beider Seiten der Bahn (W) und zum anschließenden Trocknen beider Seiten der befeuchteten Bahn aufweist, um die Einrolltendenz wesentlich zu reduzieren, die sich in der Bahn in der Vorwärtstrocknerpartie ergibt.

7. Verfahren nach einem der Ansprüche 1 bis 6, ferner mit den Schritten:

    Leiten der Bahn (W) in der Endbearbeitungspartie (D2) durch eine Vorrichtung (20) zur doppelseitigen Beschichtung,
    Beschichten und Befeuchten beider Seiten der Bahn (W) in der Beschichtungsvorrichtung (20),
    Leiten der Bahn (W) von der Beschichtungsvorrichtung (20) zu der Endbearbeitungstrockner-

einheit und durch diese hindurch, und
Leiten der Bahn von der Endbearbeitungstrocknereinheit (R_{21}, R_{22}) zu dem Maschinenkalander (40) und durch diesen hindurch, und anschließendes Leiten der Bahn von dem Maschinenkalander (40) zu einem Maschinenaufroller (50), oder
Leiten der Bahn (W) von der Endbearbeitungstrocknereinheit (R_{21}, R_{22}) unmittelbar zu einem Maschinenaufroller (50).

8. Verfahren nach einem der Ansprüche 1 bis 6, wobei die Endbearbeitung der Bahn in den Schritten b1 und b2 die Schritte aufweist:

Befeuchten und Beschichten von lediglich einer ersten Seite (W_y) der Bahn (W_k) und Leiten der Bahn durch die Endbearbeitungstrocknereinheit, und anschließend
Befeuchten und Beschichten einer zweiten Seite (W_a) der Bahn gegenüber der ersten Seite und Leiten der Bahn durch eine zusätzliche Endbearbeitungstrocknereinheit.

9. Verfahren nach einem der Ansprüche 1 bis 7, wobei die Endbearbeitung der Bahn in den Schritten b1 und b2 die Schritte aufweist.

Befeuchten der Bahn (W) in der Endbearbeitungspartie (D2),
Leiten der befeuchteten Bahn durch zumindest eine Gruppe (R_{22}) mit Doppelsiebführung der Endbearbeitungseinheit,
Ausüben einer Trocknungswirkung in der Doppelsiebführungsgruppe (R_{22}) auf beide Flächen (W_a, W_y) der befeuchteten Bahn, und
Steuern der Proportion der Trocknungswirkung, die auf jede der Flächen (W_a, W_y) der Bahn ausgeübt wird, indem das Verhältnis der Oberflächentemperaturen von Trocknungszylindern (30A, 30B) in der Doppelsiebfübrungsgruppe (R_{22}) und/oder das Verhältnis der Spannungen eines Paares von Trocknungssieben (35A, 35B) in der Doppelsiebführungsgruppe (R_{22}) reguliert wird.

10. Verfahren nach einem der Ansprüche 1 bis 9, ferner mit dem Schritt zur Steuerung der Einrolltendenz der Bahn (W), indem heißer Wasserdampf auf die Bahn ausgehend von zumindest einem Dampfkasten (435, 445, 455) ausgerichtet wird.

11. Verfahren nach einem der Ansprüche 1 bis 10, ferner mit dem Schritt zur Anordnung zumindest eines Infrarottrockners, zumindest eines kontaktfreien Trockners mit schwebender Bahn und/oder eines Kombinationstrockners in der Endbearbeitungspartie (D2, D20, D21), um die Bahn zu trocknen.

12. Trockenende einer Papiermaschine zur Erzeugung von oberflächenbehandeltem Papier, mit einer Vorwärtstrocknerpartie (D1), die eingerichtet ist, um eine Papierbahn (W) von einer Pressenpartie aufzunehmen, und einer Endbearbeitungspartie (D2, D20, D21), die eingerichtet ist, um die Bahn (W) von der Vorwärtstrocknerpartie (D1) aufzunehmen, wobei

die Vorwärtstrocknerpartie (D1) über ihre gesamte Länge (L) aus Trocknergruppen (R_1 bis R_8) mit Einzelsiebführung zusammengesetzt ist, wobei jede der Gruppen (R_1 bis R_8) nach unten offen ist und dampfbeheizte Trocknungszylinder (10), ein Trocknungssieb (15) zum Tragen der Bahn (W) und zum Pressen der Bahn in unmittelbarem Kontakt mit den Trocknungszylindern (10), und Umkehrsaugzylinder (11) aufweist, die in einer Schleife des Trocknungssiebes (15) eingerichtet sind, **dadurch gekennzeichnet, dass** die Endbearbeitungspartie (D2, D20, D21) zumindest eine Oberflächenleimungsvorrichtung, eine Pigmentiervorrichtung oder eine Beschichtungsvorrichtung (20) aufweist und ferner eine Endbearbeitungstrocknereinheit aufweist, die stromab der Vorrichtung oder Vorrichtungen angeordnet, ist, wobei die Endbearbeitungspartie (D2, D20, D21) die Bahn (W) mit Hilfe der Oberflächenleimungsvorrichtung und/oder der Pigmentiervorrichtung und/oder der Beschichtungsvorrichtung (20, 20A, 120) derart befeuchtet, dass eine Einrolltendenz der Bahn (W), die sich in der Vorwärtstrocknerpartie (D1) ergibt, wesentlich reduziert wird.

13. Trockenende nach Anspruch 12, wobei die Endbearbeitungspartie (D2) zumindest einen Maschinenkalander (40, 40A) zur plastischen Bearbeitung der Bahn (W) aufweist.

14. Trockenende nach Anspruch 13, wobei der zumindest eine Maschinenkalander (40, 40A) ein Weichkalander ist.

15. Trockenende nach einem der Ansprüche 12 bis 14, wobei die Endbearbeitungspartie (D2) eine Online-Prozessstraße ist, die mit der Vorwärtstrocknerpartie (D1) verbunden ist und einen Maschinenaufroller (50) an der Endseite der Prozessstraße aufweist.

16. Trockenende nach Anspruch 12 oder 14, wobei die Endbearbeitungspartie (D20, D21) eine Offline-Einheit ist, die von der Vorwärtstrocknerpartie (D1) separiert ist.

17. Trockenende nach einem der Ansprüche 12 bis 16, wobei die Endbearbeitungstrocknereinheit zumindest eine Gruppe (R_{22}) mit Doppelsiebführung aufweist, die eine Steuereinrichtung enthält, die in Ver-

bindung damit zur Steuerung der Relativproportionen der auf die Flächen (W_a, W_y) der Bahn ausgeübten Trocknungseffekte eingerichtet ist.

18. Trockenende nach einem der Ansprüche 12 bis 17, wobei die Endbearbeitungspartie (D2, D20, D21) zumindest eine Infrarottrocknereinheit, zumindest eine Trocknereinheit mit luftgetragener Bahn und/oder zumindest eine Infraroteinheit mit Luftstützung aufweist.

19. Trockenende nach einem der Ansprüche 12 bis 18, ferner mit

einem Fertigungsausschussfördergerät (19, 19a, 19b), das zumindest unterhalb angeordnet ist und sich über die gesamte Länge der Vorwärtstrocknerpartie (D1) erstreckt, wobei das Fertigungsausschussfördergerät Papierausschuss (WS) aufnimmt, das in den Trocknergruppen (R_1 bis R_8) mit Einzelsiebführung erzeugt worden ist, und
einem Stofflöser (19c), in welchem das Fertigungsausschussfördergerät den Papierfertigungsausschuss fördert.

20. Trockenende nach Anspruch 19, wobei das Fertigungsausschussfördergerät (19, 19a, 19b) sich überzumindest einen Teil der Länge der Endbearbeitungspartie (D2) erstreckt.

Revendications

1. Procédé de fabrication de papier à surfaces travaillées, à partir d'une bande de papier ayant été déshydratée, par compression, sensiblement jusqu'à une première part de solides secs renfermée comprise entre environ 35 % et environ 60 %, ledit procédé comprenant les étapes consistant à :

a1) sécher la bande (W), dans une zone antérieure de séchage (D1), sensiblement jusqu'à une seconde part de solides secs renfermée comprise entre 90 % et 99 % ;
a2) le séchage de la bande, à l'étape al, englobant l'étape consistant à soumettre la bande à une énergie de séchage, sensiblement sur toute la longueur (L) de la zone antérieure de séchage (D1), de manière asymétrique dans la direction z, à partir de l'une (W_a) des faces de la bande (W) ;
a3) la bande étant soumise de manière asymétrique à l'énergie de séchage, durant l'étape a2, en faisant défiler ladite bande (W) à travers une pluralité de groupes sécheurs successifs (R_1 à R_8) à traction de toile unique, qui sont ouverts vers le bas, de telle sorte que la bande (W) ait tendance à se gondoler par suite de son séchage asymétrique dans la zone antérieure de séchage (D1) ;

ledit procédé étant caractérisé par les étapes consistant à :

b1) transférer la bande (W) de la zone antérieure de séchage (D1) vers une zone de finissage (D2, D20, D21) qui comprend au moins un dispositif de dimensionnement superficiel, un dispositif de pigmentation ou un dispositif de revêtement (20, 20A, 120), ladite zone de finissage (D2, D20, D21) comprenant en outre une unité de séchage de finition implantée en aval dudit ou desdits dispositif(s) ; et
b2) humidifier la bande (W) dans la zone de finissage (D2, D20, D21), au moyen dudit dispositif de dimensionnement superficiel et/ou dudit dispositif de pigmentation et/ou dudit dispositif de revêtement (20, 20A, 120), de telle sorte que la tendance de la bande (W) à se gondoler, qui est survenue dans la zone antérieure de séchage (D1), soit notablement réduite.

2. Procédé selon la revendication 1, dans lequel la bande (W) est travaillée plastiquement dans la zone de finissage (D2), au moyen d'une calandre (40, 40A) de la machine.

3. Procédé selon la revendication 1 ou 2, comprenant par ailleurs l'étape d'élimination du cassé, sensiblement par gravité, à partir de la région sous-jacente aux groupes sécheurs (R_1 à R_8) qui sont ouverts vers le bas.

4. Procédé selon l'une des revendications 1 à 3, comprenant par ailleurs une exécution enchaînée des étapes a1, a2, a3, b1 et b2, en un défilement continu de la bande.

5. Procédé selon l'une des revendications 1 à 3, comprenant par ailleurs les étapes de transfert de la bande (W) à une enrouleuse de la machine après la zone antérieure de séchage (D1), et l'exécution des étapes bl et b2 en tant qu'étapes extérieures à la machine après que la bande a été bobinée, puis déroulée.

6. Procédé selon l'une des revendications 1 à 5, dans lequel le finissage de la bande, aux étapes bl et b2, comprend les étapes consistant à humidifier les deux faces de la bande (W), puis à sécher les deux faces de la bande humidifiée, afin de réduire notablement la tendance au gondolage qui est survenue, dans ladite bande, dans la zone antérieure de séchage.

7. Procédé selon l'une des revendications 1 à 6, comprenant par ailleurs les étapes consistant à :

faire défiler la bande (W), dans la zone de finissage (D2), à travers un dispositif (20) de revêtement double-face,
revêtir et humidifier les deux faces de la bande (W), dans ledit dispositif de revêtement (20),
faire défiler la bande (W), à partir dudit dispositif de revêtement (20), vers et à travers ladite unité de séchage de finition, et
faire défiler la bande, à partir de ladite unité (R_{21}, R_{22}) de séchage de finition, vers et à travers une calandre (40) de la machine, puis transférer la bande de ladite calandre (40) de la machine à une enrouleuse (50) de la machine, ou
transférer directement la bande (W) de ladite unité (R_{21}, R_{22}) de séchage de finition à une enrouleuse (50) de la machine.

8. Procédé selon l'une des revendications 1 à 6, dans lequel le finissage de la bande, aux étapes b1 et b2, comprend les étapes consistant à

humidifier et revêtir uniquement une première face (W_y) de la bande (W_k), et faire défiler la bande à travers ladite unité de séchage de finition, puis à
humidifier et revêtir une seconde face (W_a) de la bande, tournée à l'opposé de ladite première face, et faire défiler la bande à travers une unité supplémentaire de séchage de finition.

9. Procédé selon l'une des revendications 1 à 7, dans lequel le finissage de la bande, aux étapes b1 et b2, comprend les étapes consistant à

humidifier la bande (W) dans la zone de finissage (D2),
faire défiler la bande humidifiée à travers au moins un groupe (R_{22}) à traction double toile de ladite unité de séchage de finition,
exercer, dans le groupe (R_{22}) à traction double toile, un effet de séchage sur les deux faces (W_a, W_y) de la bande humidifiée, et
commander la proportion de l'effet de séchage exercé sur chacune des faces (W_a, W_y) de la bande, en régulant le rapport des températures superficielles de cylindres sécheurs (30A, 30B), dans le groupe (R_{22}) à traction double toile, et/ou le rapport des tensions d'une paire de toiles de séchage (35A, 35B) dans ledit groupe (R_{22}) à traction double toile.

10. Procédé selon l'une des revendications 1 à 9, comprenant par ailleurs l'étape consistant à commander la tendance de la bande (W) à se gondoler en dirigeant de la vapeur d'eau chaude, sur ladite bande, à partir d'au moins un caisson de vapeur (435, 445, 455).

11. Procédé selon l'une des revendications 1 à 10, comprenant par ailleurs l'étape consistant à installer au moins une sécheuse à infrarouges, au moins une sécheuse sans contact à sustentation pneumatique et/ou une sécheuse combinée, dans la zone de finissage (D2, D20, D21), afin de sécher la bande.

12. Partie sèche d'une machine à papier pour produire du papier à surfaces travaillées, comprenant une zone antérieure de séchage (D1) conçue pour recevoir une bande de papier (W) provenant d'une zone de compression, et une zone de finissage (D2, D20, D21) conçue pour recevoir la bande (W) provenant de ladite zone antérieure de séchage (DI),

ladite zone antérieure de séchage (D1) étant composée, sur toute sa longueur (L), de groupes sécheurs (R_1 à R_8) à traction de toile unique, chacun desdits groupes (R_1 à R_8) étant ouvert vers le bas et comprenant des cylindres sécheurs (10) chauffés par de la vapeur, une toile de séchage (15) pour supporter la bande (W) et pour presser ladite bande au contact direct desdits cylindres sécheurs (10), et des cylindres inverseurs (11) à aspiration, agencés dans une boucle de ladite toile de séchage (15), caractérisée par le fait que ladite zone de finissage (D2, D20, D21) comprend au moins un dispositif de dimensionnement superficiel, un dispositif de pigmentation ou un dispositif de revêtement (20) et comprend, en outre, une unité de séchage de finition implantée en aval dudit ou desdits dispositif(s), ladite zone de finissage (D2, D20, D22) humidifiant la bande (W) au moyen dudit dispositif de dimensionnement superficiel et/ou dudit dispositif de pigmentation et/ou dudit dispositif de revêtement (20, 20A, 120), de telle sorte qu'une tendance de la bande (W) à se gondoler, survenant dans ladite zone antérieure de séchage (D1), soit notablement réduite.

13. Partie sèche selon la revendication 12, dans laquelle ladite zone de finissage (D2) comprend au moins une calandre (40, 40A) de la machine, pour travailler plastiquement la bande (W).

14. Partie sèche selon la revendication 13, dans laquelle ladite calandre (40, 40A) de machine, prévue au minimum, est une calandre douce.

15. Partie sèche selon l'une des revendications 12 à 14, dans laquelle ladite zone de finissage (D2) est une

ligne de traitement en continu reliée à ladite zone antérieure de séchage (D1), et comprend une enrouleuse (50) de machine située à une extrémité distale de ladite ligne de traitement.

16. Partie sèche selon la revendication 12 ou 14, dans laquelle ladite zone de finissage (D20, D21) est une unité autonome séparée d'avec ladite zone antérieure de séchage (D1).

17. Partie sèche selon l'une des revendications 12 à 16, dans laquelle ladite unité de séchage de finition comprend au moins un groupe (R_{22}) à traction double toile, incluant des moyens de commande qui y sont raccordés afin de commander les proportions relatives des effets de séchage exercés sur les faces (W_a, W_y) de la bande.

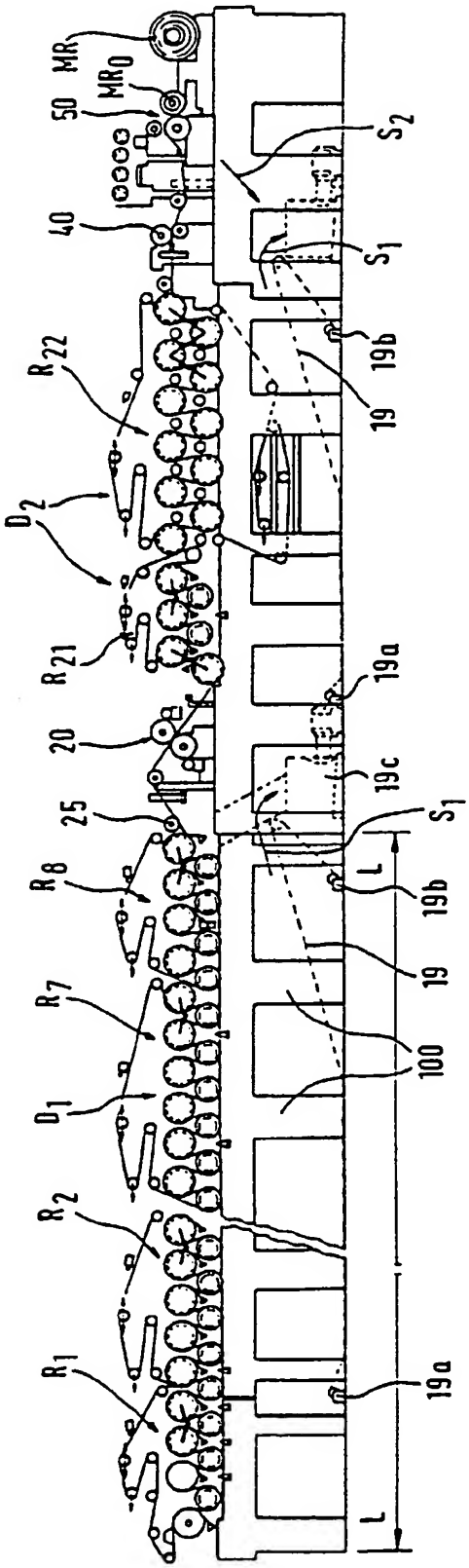
18. Partie sèche selon l'une des revendications 12 à 17, dans laquelle ladite zone de finissage (D2, D20, D21) comprend au moins une unité de séchage aux infrarouges, au moins une unité de séchage à sustentation pneumatique et/ou au moins une unité à infrarouges à sustentation pneumatique.

19. Partie sèche selon l'une des revendications 12 à 18, comprenant en outre

    un convoyeur (19, 19a, 19b) de cassé, agencé au moins au-dessous de ladite zone antérieure de séchage (D1) pour en embrasser toute la longueur, ledit convoyeur de cassé recevant du cassé (WS) engendré dans lesdits groupes sécheurs (R_1 à R_8) à traction de toile unique, et
    un broyeur (19c) dans lequel ledit convoyeur de cassé convoie le cassé.

20. Partie sèche selon la revendication 19, dans laquelle ledit convoyeur (19, 19a, 19b) de cassé s'étend sur au moins une partie de la longueur de ladite zone de finissage (D2).

FIG. 1


MR
MR0
50
40
R22
D2
R21
20
25
R8
R7
D1
R2
R1
S2
S1
19b
19
19a
19c
100
L

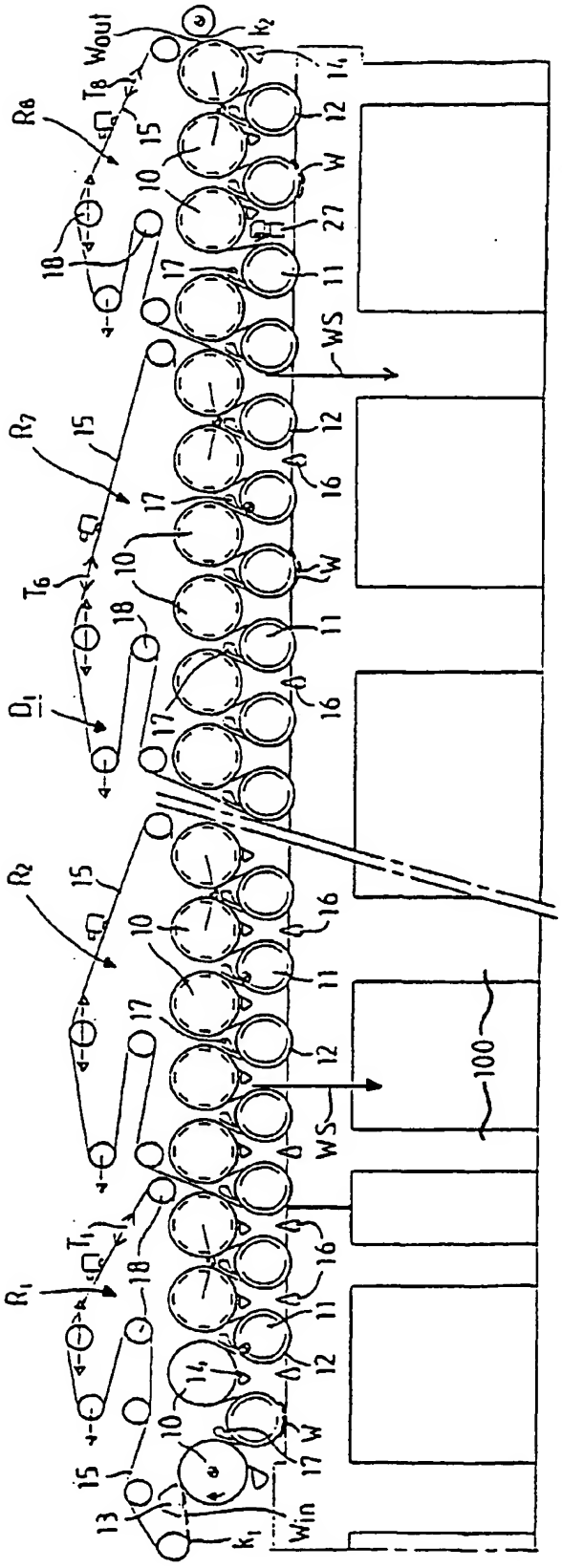
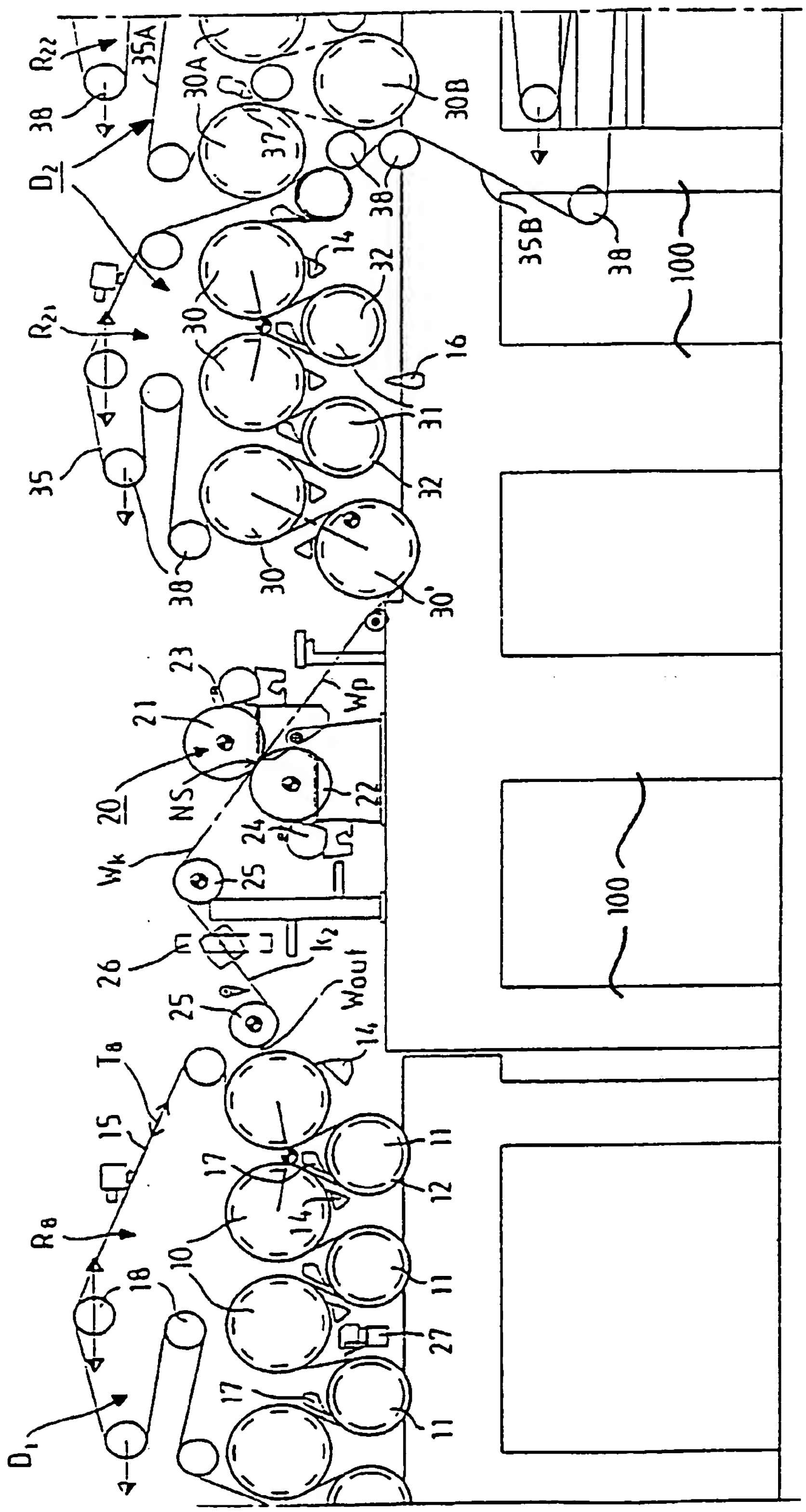
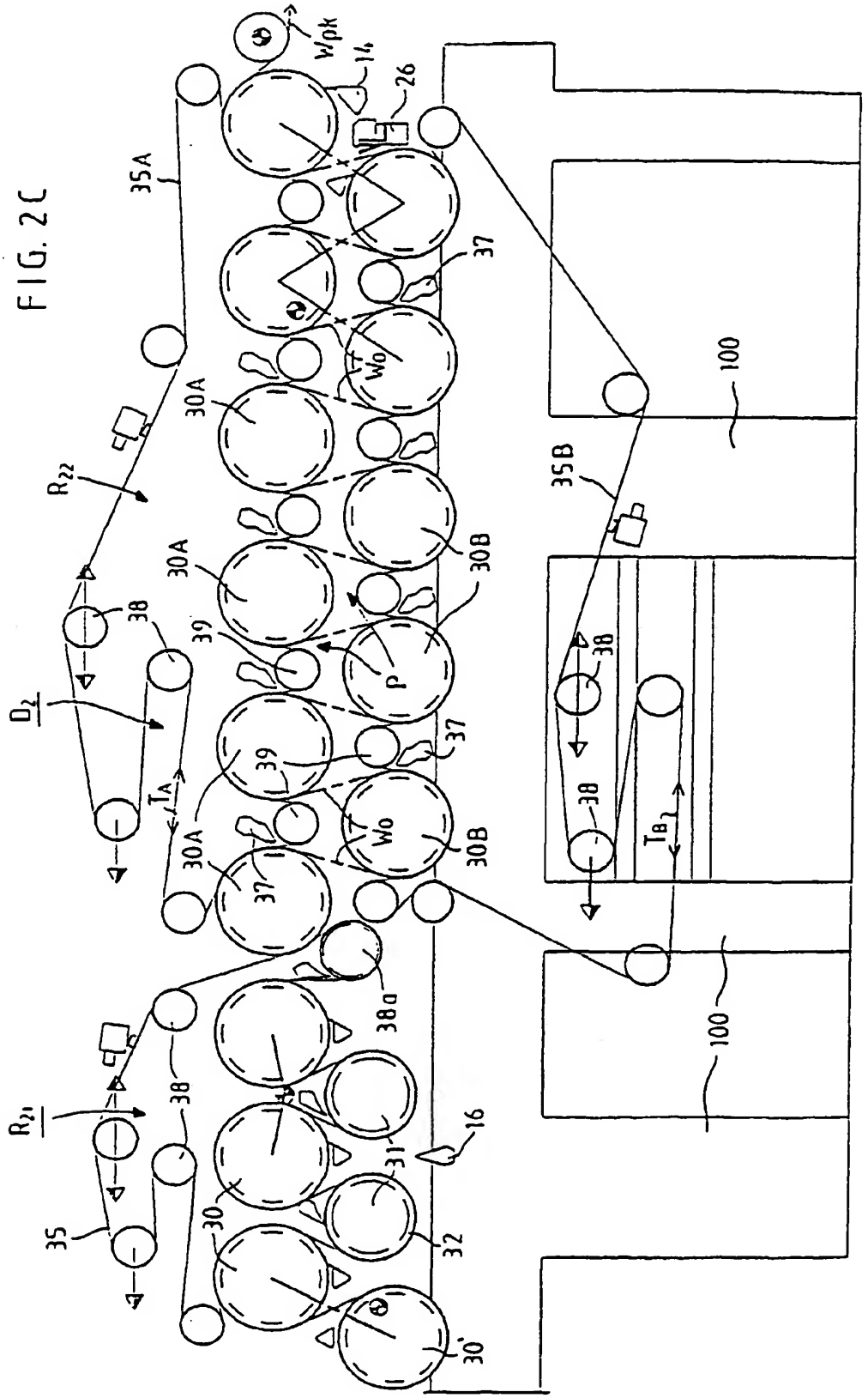


FIG. 2A


D1
D2
R8
R21
R22
T8
15
18
10
17
14
11
12
27
25
26
K2
Wout
Wk
NS
20
21
22
23
24
Wp
30
30'
30A
30B
31
32
35
35A
35B
37
38
16
100

F I G. 2 B

FIG. 2C


Wpk
14
26
35A
37
Wo
30A
30B
R22
38
39
P
D2
TA
TB2
100
35B
38a
R21
35
30
31
32
16
30'

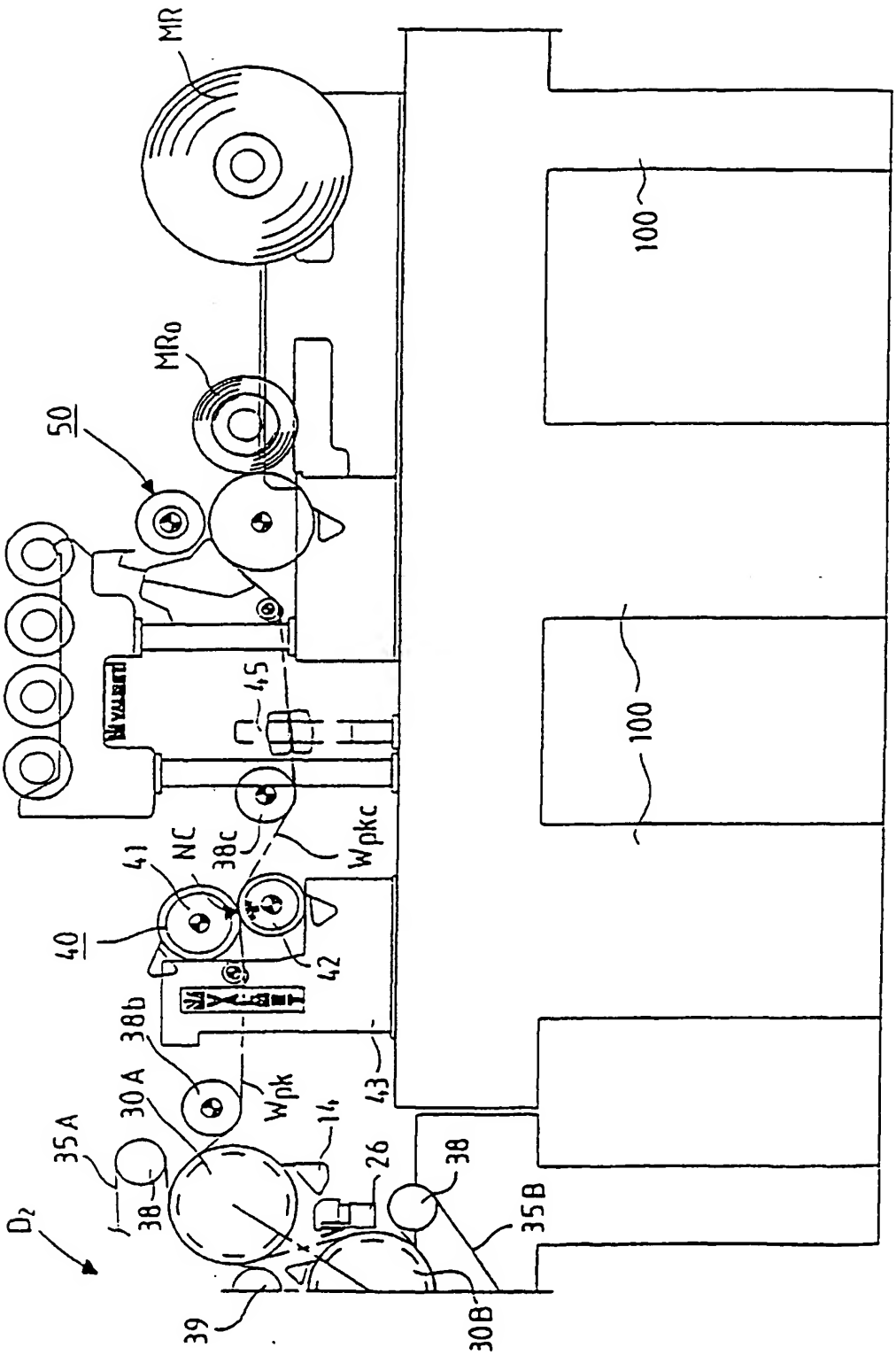
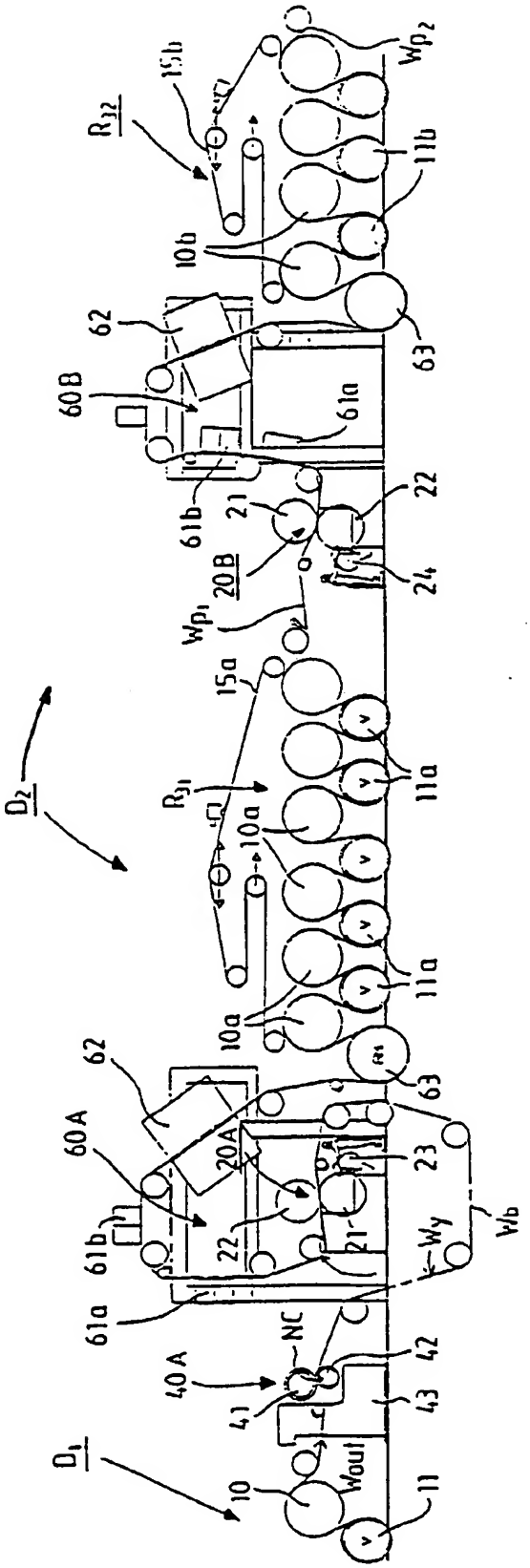

MR
MRo
50
100
100
45
41
NC
38c
Wpkc
40
42
38b
30A
Wpk
43
35A
14
26
38
38
35B
D2
39
30B

FIG. 2D

FIG. 3


D1
D2
10
11
40A
41
42
43
NC
Wout
60A
60B
61a
61b
62
63
20A
20B
21
22
23
24
P1
10a
11a
15a
15b
R31
R32
Wy
Wb
Wp1
Wp2

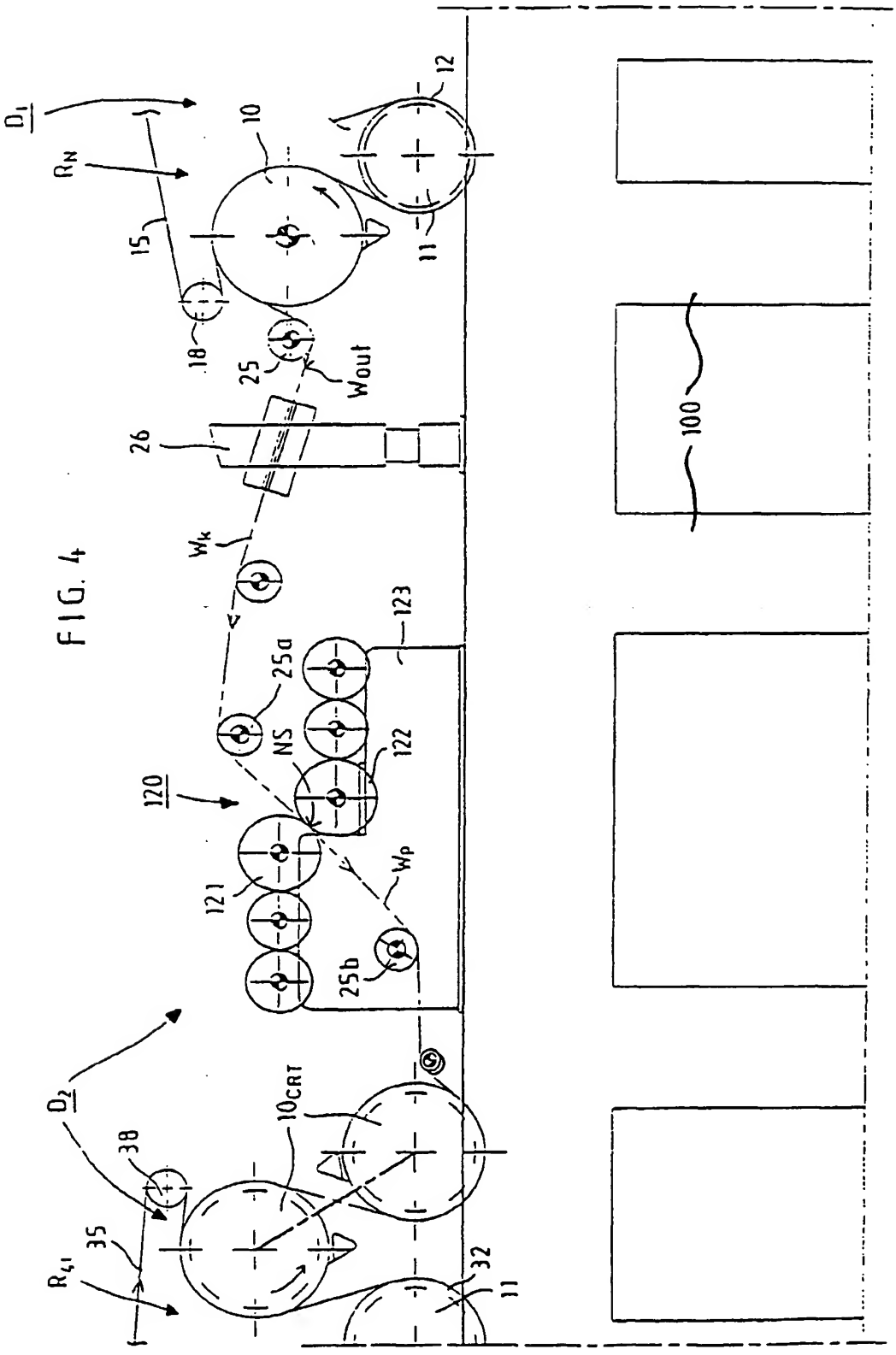

D1
RN
15
18
10
12
11
25
Wout
26
Wk
100
123
25a
NS
122
120
121
Wp
25b
D2
38
10CRT
35
R41
32
11

FIG. 4

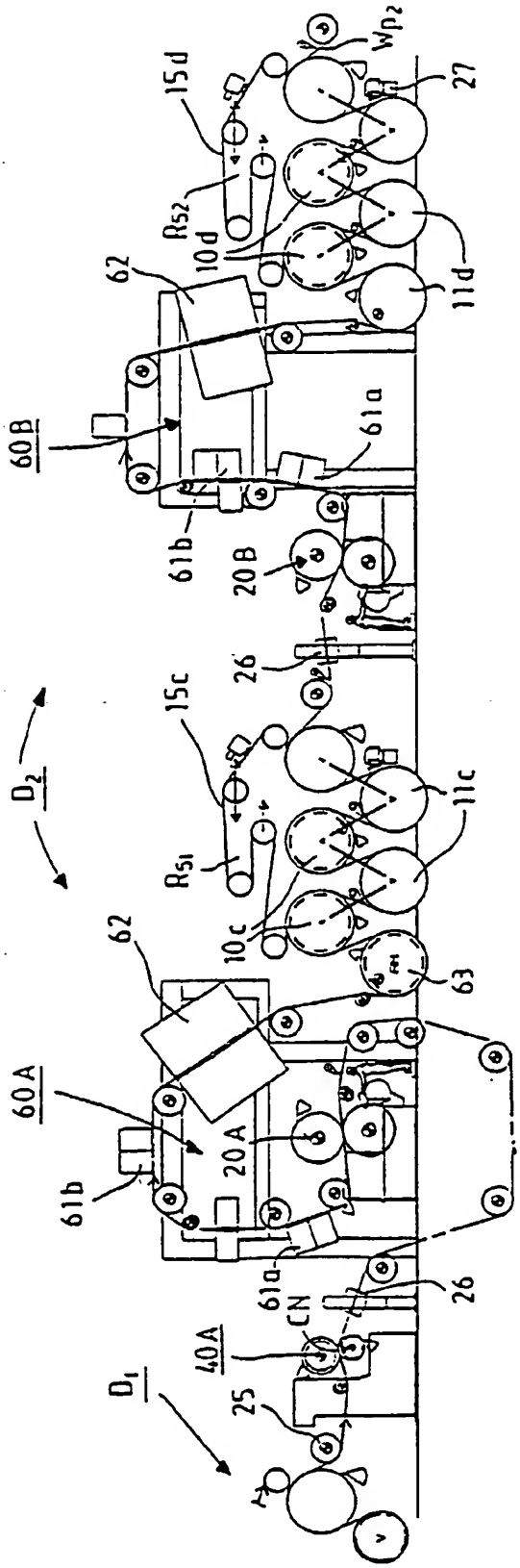

Wp2
27
15d
Rs2
10d
11d
62
60B
61a
61b
20B
26
15c
D2
Rs1
10c
11c
63
62
60A
20A
61b
61a
26
CN
40A
25
D1

FIG. 5

FIG. 6

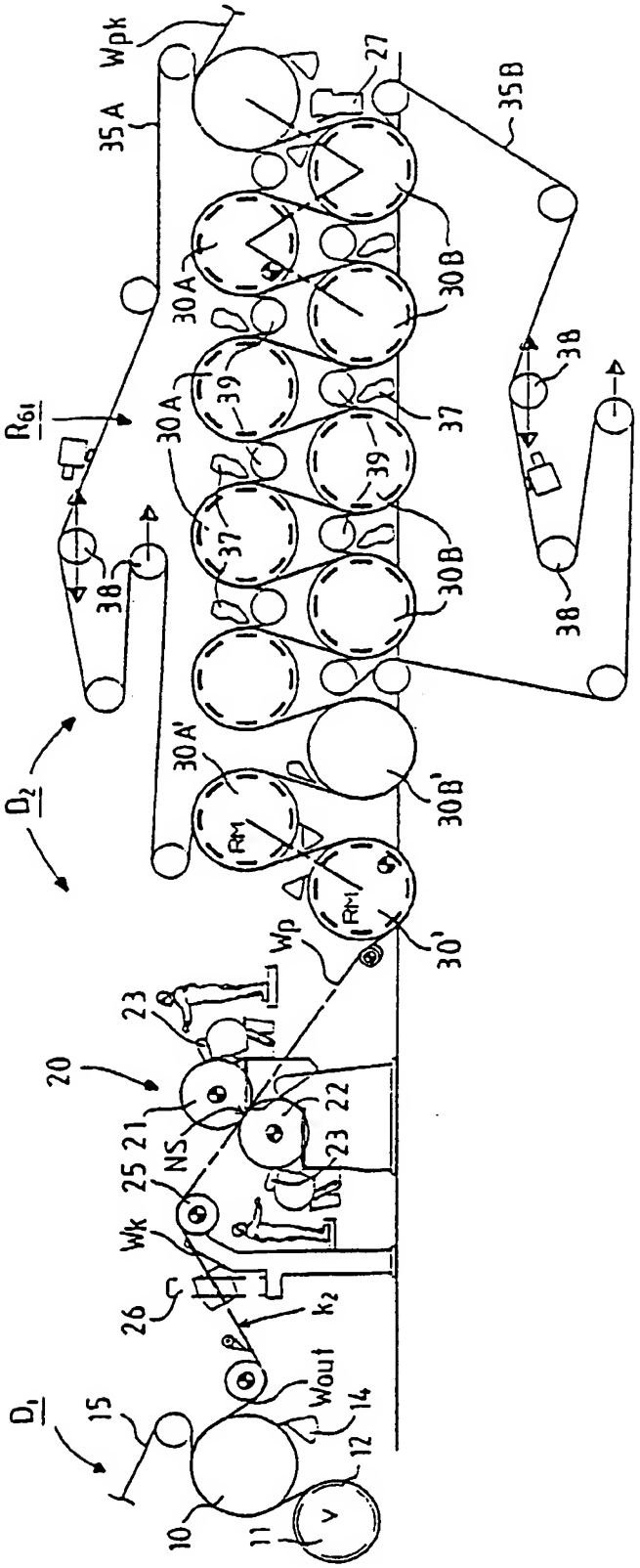
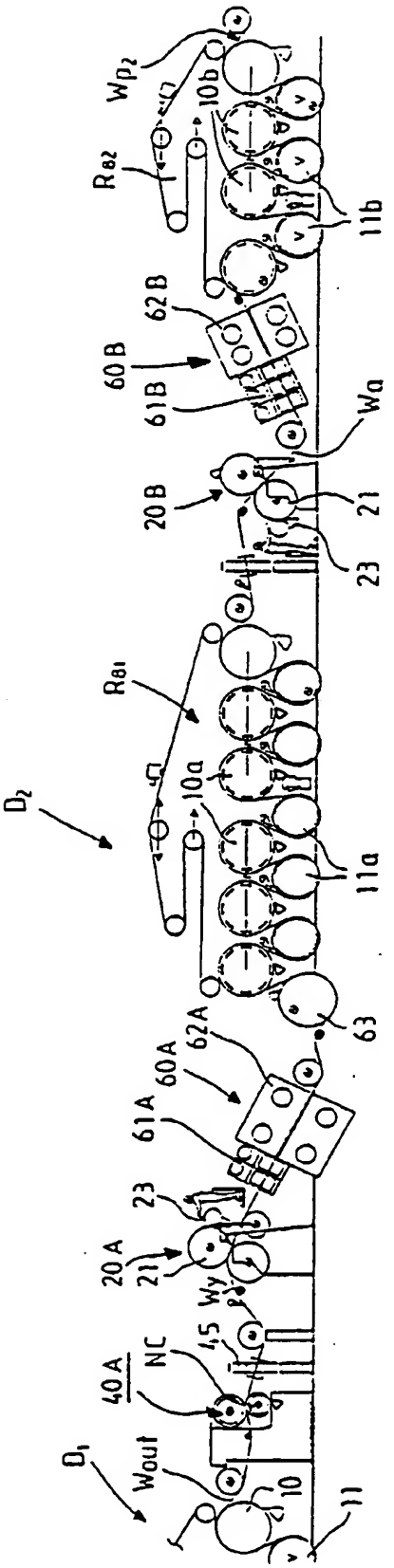

Wpk
35A
27
35B
30A
30B
38
37
39
R_{61}
D_2
30A'
30B'
Rm1
30'
Wp
23
20
21
22
25
NS
Wk
26
k_2
Wout
D_1
15
14
12
10
11
V

FIG.7


W_{p2}
10b
R_{82}
11b
62B
60B
61B
W_a
20B
21
23
R_{81}
D_2
10a
11a
63
62A
60A
61A
23
20A
21
W_y
4,5
40A
NC
D_1
W_{out}
10
11

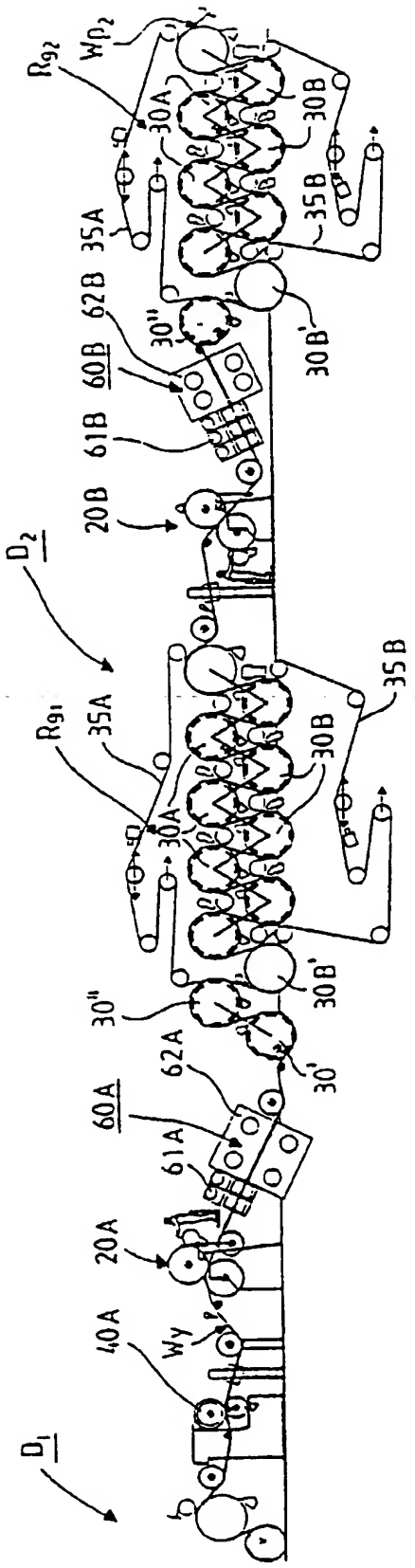

R_{92}
W_{D2}
30A
30B
35B
35A
62B
60B
61B
30"
30B'
20B
D_2
R_{91}
35A
30A
30B
35B
30"
30B'
62A
60A
61A
30'
20A
40A
W_y
D_1

FIG. 8

FIG. 9

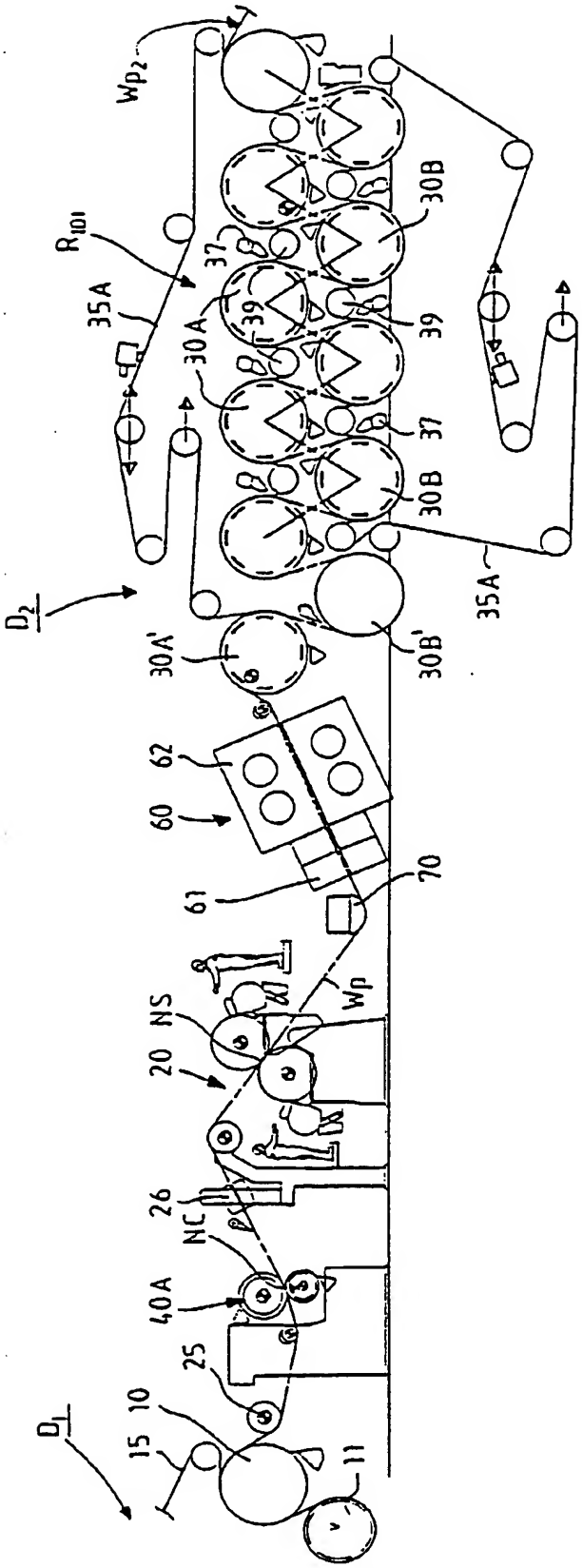
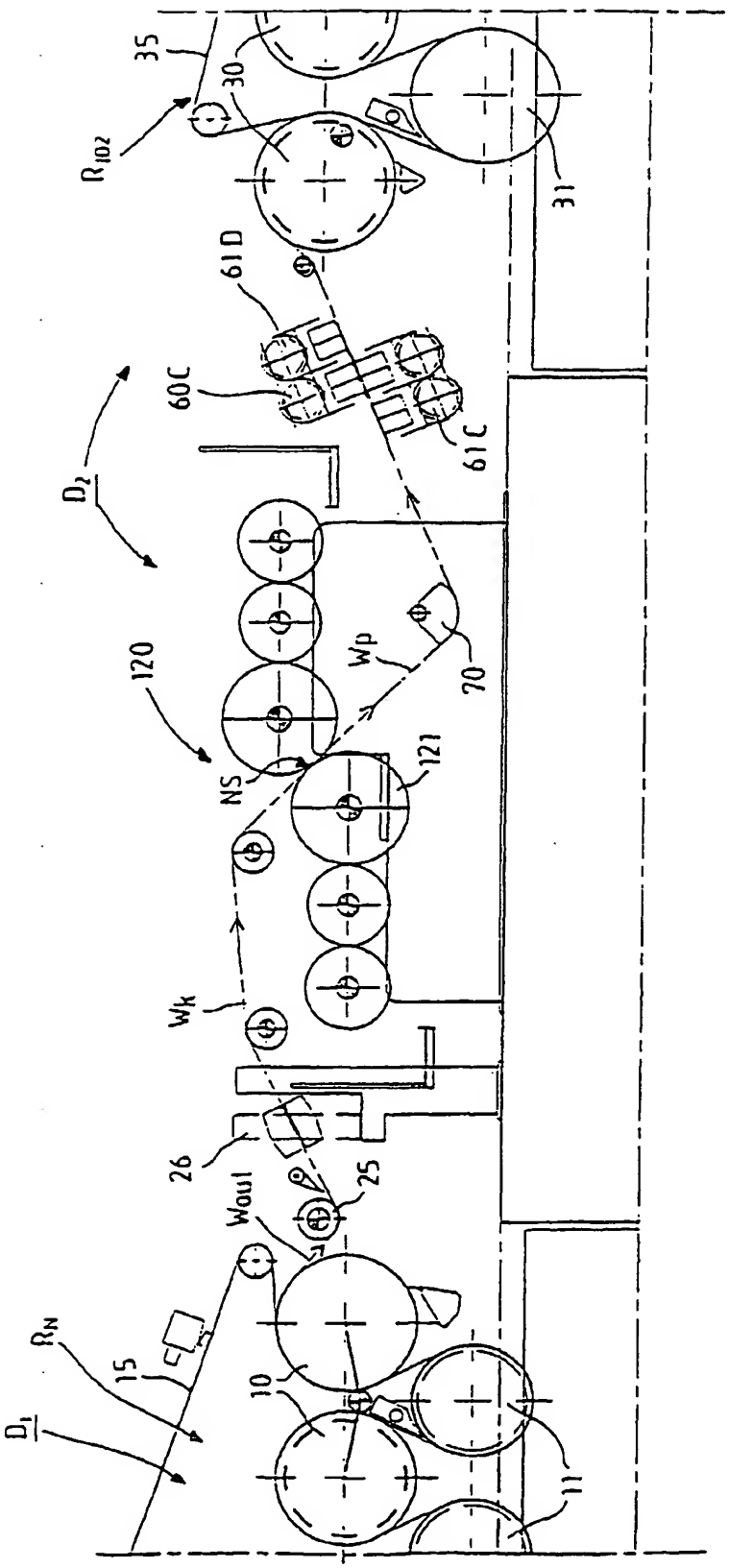

Wp2
R101
35A
30A
37
39
30B
D2
30A'
30B'
62
60
61
70
Wp
NS
20
26
NC
40A
25
10
15
D1
11

FIG. 10


35
30
R_{102}
31
61D
60C
61C
D_2
120
Wp
70
NS
121
Wk
26
25
Waul
R_N
15
D_1
10
11

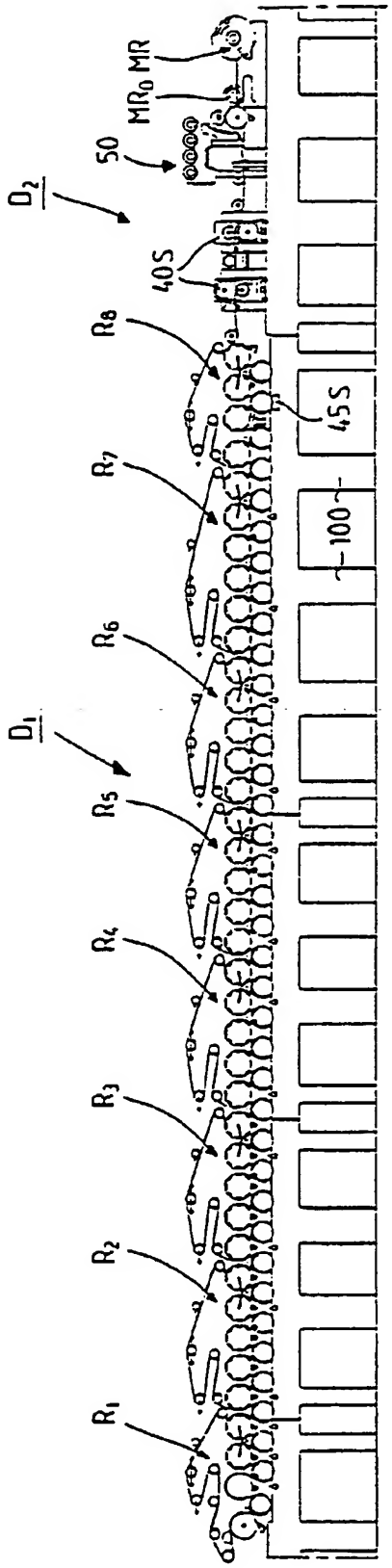


FIG. 11

FIG. 11A

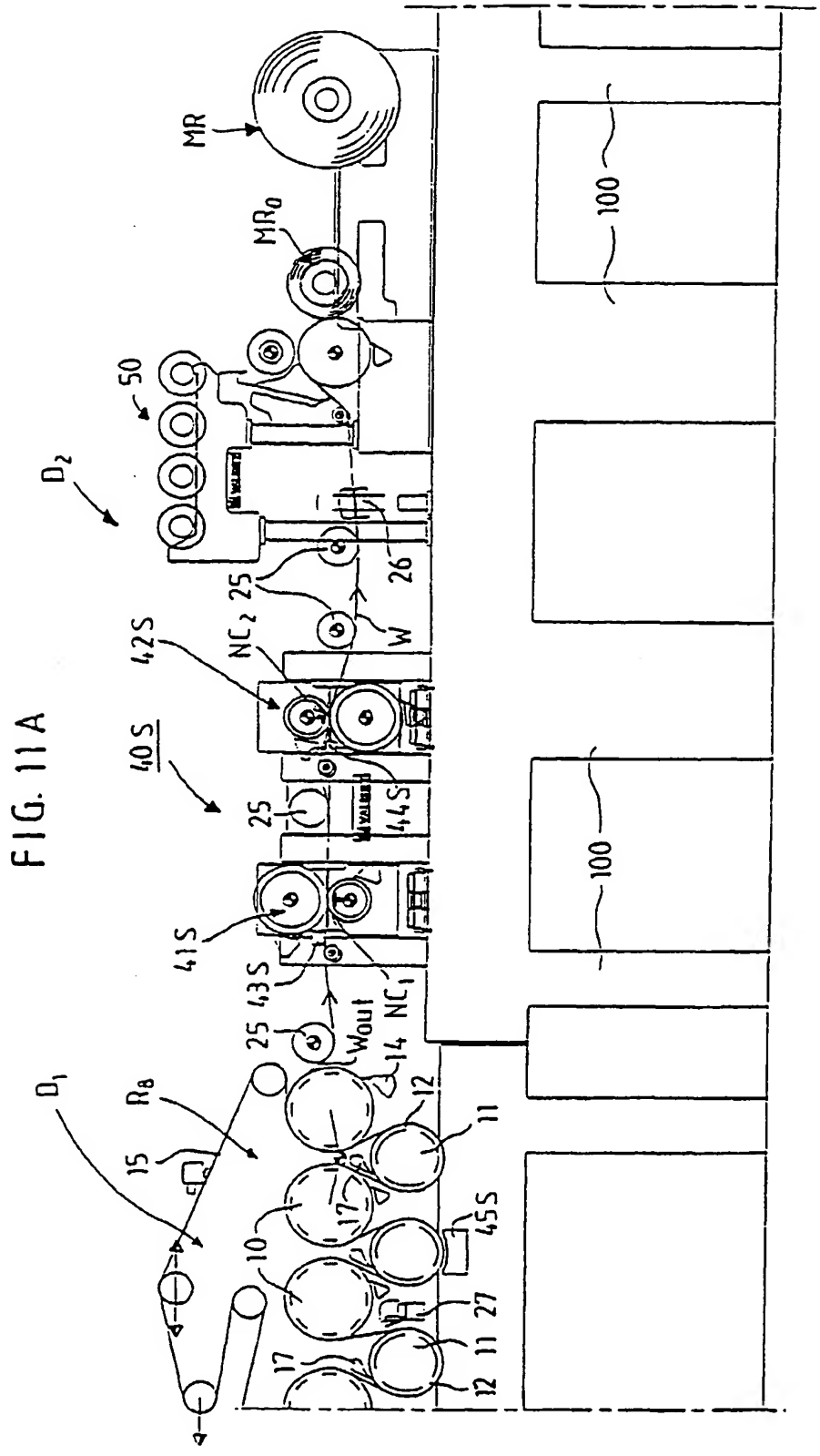

MR
MR0
50
D2
25
26
W
NC2
42S
40S
44S
41S
43S
Wout
NC1
14
12
11
D1
R8
15
17
10
45S
27
100

FIG. 12

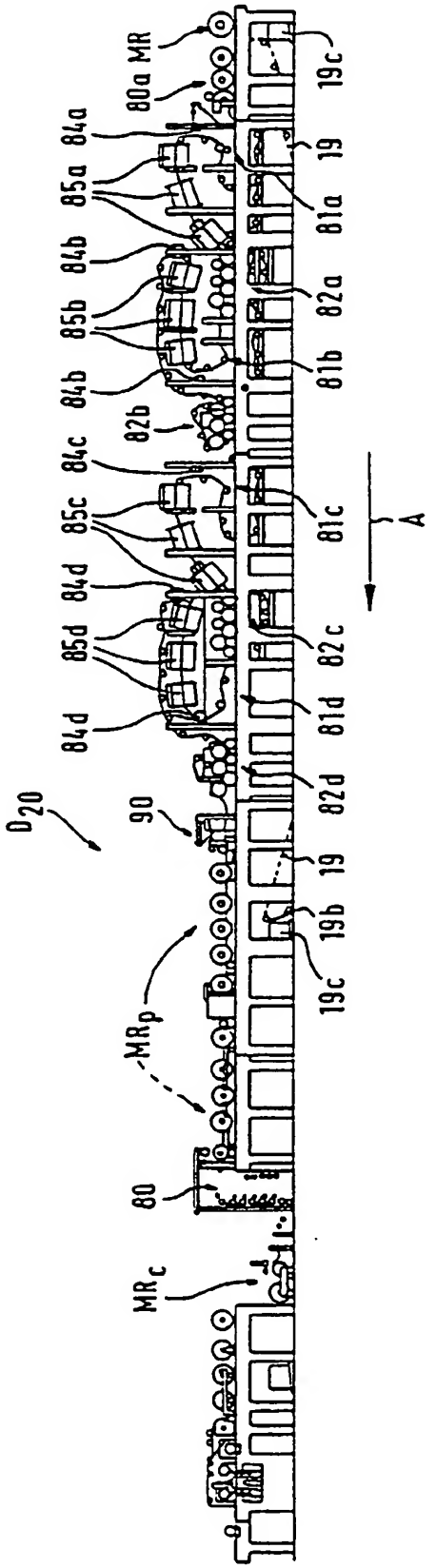
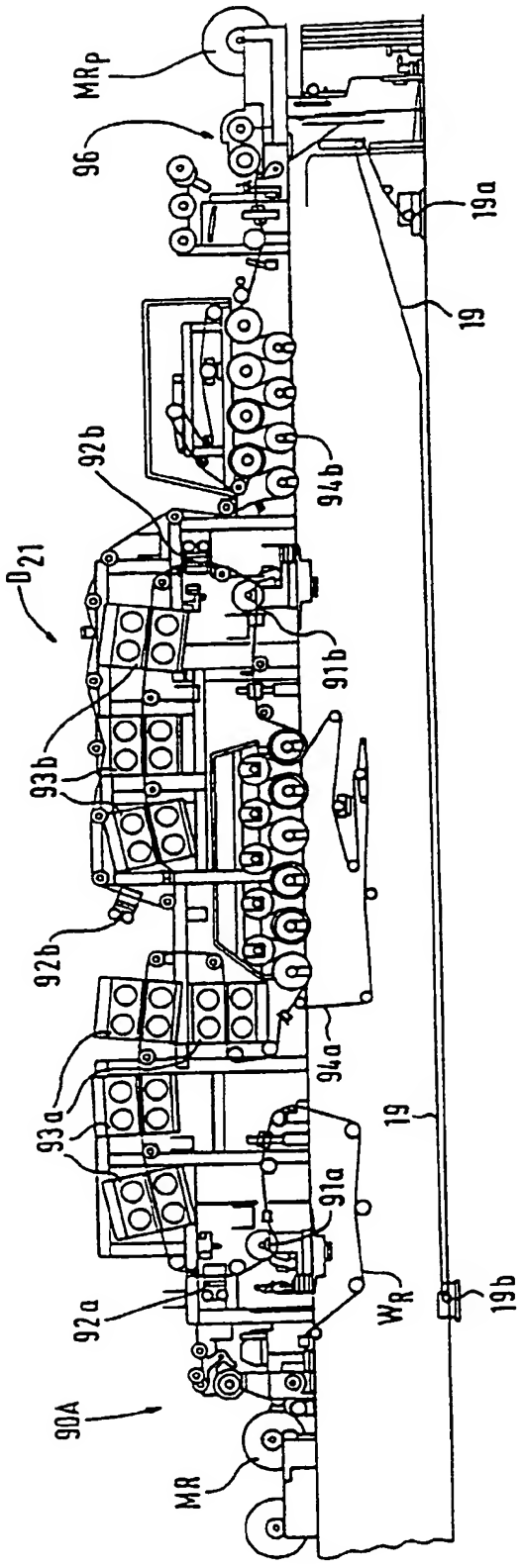

80a MR
19c
84a
19
85a
81a
84b
82a
85b
81b
84b
82b
84c
85c
81c
A
84d
85d
82c
84d
81d
90
82d
D20
19
19b
19c
MRp
80
MRc

FIG. 13


MRp
96
19a
19
92b
94b
D21
91b
93b
92b
94a
93a
19
91a
92a
WR
19b
90A
MR